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# SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

**A Journal for all SCIENCE AND MATHEMATICS TEACHERS**

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# SCHOOL SCIENCE AND MATHEMATICS

VOL. XXX No. 2 FEBRUARY, 1930 WHOLE No. 256

## AIMS IN HIGH SCHOOL BIOLOGY.

BY JEROME ISENBARGER.

There has never been a time when secondary school science has been held in higher regard than at present. The greatest need now is for a unified program of science in the school including the work of the lower grades and continuing through the junior and senior high schools. There is too much lost motion because of the fact that there is no well defined basis at any particular level upon which to build. Before the best course in science can be planned for the ninth grade level, it must be known what work has been done in science in the grades below the ninth grade. And this is correspondingly true of the work at any other place in the course.

Then we need to recognize the functions of the science subjects in the school curriculum. It should be kept in mind that general science is primarily a study of the environment. It is a study of the environment made real to the boy or girl by means of the science. The special sciences, physics and chemistry, on the other hand, should lead to understandings of scientific principles which are illustrated by things and phenomena of the environment. General science centers in the environment,—special science centers in the science.

Biology occupies the transitional position. We teach students in the biological subjects in order to provide a background of knowledge and understandings of principles upon which to base civic and economic applications, and at the same time the student's eyes should be opened to the great out-of-doors. Biology should be presented as a principles course, but the nature-study phase of the subject should receive its share of emphasis in order that the boy and girl may acquire habits of seeing which will

persist as they go through life. They need to know that insects destroy millions in grain, fruits and vegetables each year, and they should realize something of what can be done about it if everybody helps. But the book of nature revealing the secrets of the trees, the birds, and the bees must be opened to them, and they will be better citizens, as a result, in a world where co-operation should be the by-word.

Above all, biology should be a live study of life. Understandings of the phenomena of life and adaptations for living in a world of living things cannot be developed in tenth grade pupils by dissections of dead material. No laboratory study of plant or animal forms should be made at this stage of development which cannot be done with living specimens representing at least one stage of the life history studied.

Teachers who have been well trained in methods of research, but poorly trained in the technique of instruction are in constant danger of placing the emphasis mainly on subject-matter. Too many teachers consider the important part of a curriculum to be an outline of subjects to be covered in the course. It should provide this, but it should also provide a statement of understandings, attainments and adaptations to be developed. The chief attention should be centered in the pupil rather than in the subject. Experience and pedagogical training both help teachers in developing in themselves the power to view these problems with a correct perspective. Probably herein lies the reason why administrators are so insistent in their demands for experience or professional training when they engage teachers.

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## PROGRESS IN BIOLOGY COURSES.

In general teachers who have recently entered the profession and students preparing for teaching do not realize the fundamental changes in objectives, subject matter and methods of teaching that are being brought about by the progress made by scientific research in subject matter and in education. In the preceding editorial Professor Isenbarger has pointed out some of the aims in high school biology. For the benefit of the younger teachers of biological science Mr. Worralo Whitney has prepared a brief history of biology in the Chicago high schools. A specific school system was selected because the development can be traced in concrete form and it is typical of the development all over the country. Mr. Whitney has been

closely connected with this movement from the beginning and has been a member of our editorial staff for eighteen years. His article will be found on page 148 of this issue.

## SCIENCE NOT TAUGHT.

Mr. John C. Packard sends us the following note clipped from the *Boston Transcript's* report of the meeting of the American Association for the Advancement of Science:

> A large part of what the public calls science and much of the science teaching in schools and colleges today is not really science, Dr. A. J. Goldforb, retiring chairman of the medical science section, declared.
>
> "The experimental method, properly defined, characterizes real science and differentiates it from primitive science, from pseudo-science, from non-science, from anti-science," Dr. Goldforb said. "Collections of facts do not constitute science. Fact and law worship dominates the science courses in nearly all schools and colleges."

Science objectives, subject matter and methods of teaching are now on the first page of educational literature. In our attempts to provide space and funds for the tremendous increase in enrollment every department has been put on the defensive to maintain sound methods of teaching. Tests have shown the experimental method uneconomical and ineffective. But are the tests valid and reliable? Do they really measure what they purport to measure, and how accurately do they measure? If they do not we must continue to give some attention to the opinions of great scientists. The past decade has stimulated great activity in science instruction, but are we really teaching science?

## FOR RECOGNITION OF SCIENCE CREDITS.

"The keynote of the meeting (New York State Science Teachers' Association at Syracuse December 26th and 27th) was the desire to have the sequence of science subjects and the College Entrance Diploma so arranged that the science-minded pupil may have equal opportunity with the language-minded pupil; i. e., that he may present three years of science instead of three years of language for his diploma. For the coming year the Association will work for the adoption of such a plan." This movement should have the support of every science teacher. Get your organization to work with the New York teachers.

**Faraday added billions to the wealth of the world but he never received over $300 salary in any one year.**

## THE CORAL REEFS OF THE GULF COAST.

By M. M. Wells, Ph.D.,

*President, General Biological Supply House, Chicago.*

Of all aquatic communities none is more fascinating than that of the coral reef and its environs. Much has been said and written of the startling color contrasts displayed by the inhabitants of this environment, so much in fact, that one's first impression of the coral reef, seen at close hand, is bound to be a disappointment for the coral reef that one first sees is, as a matter of fact, not brilliantly colored but is done rather, in depressing shades of gray and brown.

Collecting Corals in the Gulf of Mexico.

The explanation for this apparent contradiction in statements, lies in the fact that a coral reef consists of two distinct sub-environments, namely, the living and the dead. The dull gray and brown part of the reef, which is the part that one usually sees first, consists of all sorts of sizes and shapes of dead pieces of coral that have been cast up by the waves. This dead coral forms the real barrier reef, since it projects above the water, except at the highest tides. Seen from the mainland, at low tide, the newly emerged, dead reef appears as a long, slender, jagged, curving sliver of black rock, against a background of blue and green water.

The living coral reef is invisible from the shore at all times, since coral must be covered constantly by at least several feet of water if it is to survive. To observe the living coral, then, one must arrange to see down into the water. To accomplish this, one usually hangs over the edge of a row boat and looks down through the bottom of a glass bottomed bucket, commonly known as a waterglass. This method, while simple, has its disadvantages, not the least of which is a tendency to the production of sea sickness, since the always present ocean swell demands constant refocusing and resultant strain on the eyes. Also, the water glass covers a tantalizingly small area, and it is difficult to keep any one area in view because of the constant shifting of the position of the boat. Better equipped observers make use of the glass bottomed boat, but best of all, the method of using a diving helmet, as described by Beebe and others makes the observer a temporary part of the sub-aquatic life.

*The Animals of the Dead Reef:*

The barrier reef, with its innumerable sizes and shapes of dead pieces of coral, offers an infinitude of homes for those sea animals that protect themselves from the terror of the waves, by hiding in holes and crevices. Beginning at low tide, on the ocean side of the Tortugas reef, for instance, and proceeding landward, the writer found each day a perfect sequence of these crevice-loving inhabitants, this sequence remaining practically the same from day to day. On the outer or ocean side of the dead reef, the never-tiring waves roar reefward in their endless, but futile attempt to destroy the barricade, which they themselves have materially assisted in building. Here, in the wash of the spent rollers, one may turn over wide slabs of coral rock, to find in the honey-combed interstices, on the under side, a great number of individuals of a purple sea-egg or sea-urchin, a half hour's work rewarding the worker with a bushel basket full, providing he has not become so interested in his search as to allow some unnoticed wave, larger than its forerunners, to suddenly upset collector, basket and all, and scatter the hard-earned collection, to the mercy of the thousand small rivers that constantly rush, here and there, among the slabs and blocks of dead coral. Here, in the active surf, one may also, in overturning the coral rocks, catch a glimpse of a startled Octopus as it slides swiftly into some other hidden crevice. Occasionally, if the collector's reflexes are well trained, he may succeed in securing a firm hold on the

body of the Cephalopod, and by a slow pull, overcome the hold of the tentacles, which cling desperately by their suckers, to the rock surfaces. The pull must be a gentle one, however, for the impatient collector who attempts to snatch the animal away with a sudden jerk will ruin his specimen by breaking off one or more tentacles. A hold on the tentacles, themselves, is of absolutely no value, since the slimy surface offers no friction to the hand, and the alarmed Octopus proceeds to go away from there, like nobody's business.

GIANT SEA URCHIN.

A constant succession of snails of different species is found from outer to inner side of the reef, the most common snail, of the surf waters of the Tortugas reef, being a large striped species, not yet identified. As one works shoreward, across the reef, he finds constantly new species, providing he digs for them, for no surface-living animal could persist, on the reef, through a single high tide.

Crabs appear in a series from the large calico crab, of the outer reef, to the husky bulldog crab of the middle, and the delicate porcelain crabs of the landward side. In the small temporary pools left in the depressions on the dead reef at low tide, one finds also the ubiquitous spider crabs, creatures so ungainly and apparently so helpless that it is difficult to understand how the species should have been successful in maintaining existence. The spider crabs will be found half to wholly buried in the loose coral sediment at the bottom of the tidal pools, coming to the surface apparently as the tide recedes, but retreating to the safety of greater depths as the waves begin once more to roll across the reef, at high tide. That the ungainly spider crabs are successful in the competition for survival is clearly demon-

strated by their presence in large numbers, on every tidal flat and bayou, along our whole Atlantic and Gulf coast line. Undoubtedly the success of this peculiar form, like that of the ancient *Limulus*, is largely due to its burrowing habits, it being evident that the best shape for success in a burrowing animal is not necessarily related to that which seems most efficient in the more active aquatic and terrestrial species.

As one explores the drying reef at ebb-tide he may hear upon all sides a peculiar clicking sound which seems to come from nowhere at all. For a time this clicking was a puzzle, and I had almost decided that it was due to some hydrostatic phenomenon of the drying reef when one day I scooped out from the little pool which had seeped into the depression recently occupied by a coral boulder, a slender crustacean that clicked as I held it in my hand. Then I knew that the clicking sound was produced by the snapping or clicking shrimp, a little crawfish-like animal about three inches long.

Various species of Annelid worms are also abundant in the finer coral sand near the shore side of the reef. To the fishermen and spongers of the region, the Annelid worms are sea-centipedes, and it must be admitted that some of them are pugnacious enough to be deserving of some such vicious name. One of these species, a beautifully tender-pink worm, three to six inches long and a quarter of an inch wide, looked far too delicate to be in any way harmful. However, when this delicate creature was picked up it shot out from each side a veritable barrage or hedge of fine, white, glass-like spines, which remained sticking into my fingers. When I tried to remove these spines, they broke off at the skin surface and, as predicted by the local spongers, within a few days small irruptions, that itched continuously and severely for several days, broke out wherever the tiny spines had penetrated the skin. Another so-called sea-centipede, a slender Annelid nearly a foot and a half long by a half inch wide, broke into three pieces when captured. This valuable lesson in the process of asexual reproduction was, from my point of view, rather over-emphasized, however, when the head segment thrust out a Nereis-like proboscis armed with two pairs of sharp curved chitinous fangs and before I realized what was going on, clamped these teeth into the soft tissues of my forefinger. The teeth penetrated the flesh to their full length of about a quarter of an inch and when the worm showed no sign of letting go had to be torn free with the result that the wound bled copiously while the scar of the

somewhat painful but otherwise harmless laceration remained, for some weeks, as a reminder that once was enough.

Another species or group of species that forms a conspicuous part of the fauna of the middle and inner dead reef is the brittle-stars or serpent-stars which, like the other reef inhabitants, are found buried in the coral sand or are uncovered when some slab or boulder is overturned. Astonishingly enough, too, these apparently awkward animals disappear with considerable facility by crawling or swimming away on their long arms. If handled at all carelessly, the brittle stars at once reveal the reason for their name, by beginning to drop off pieces of the arms until, if the handling be continued, there soon remains nothing but the central disk with a short stub to indicate the position of each lost arm.

It will be seen from the foregoing, that the dead coral reef is of fascinating interest to zoologists. Botanists, on the other hand, find little here to occupy their attention for the dead reef is devoid of any visible plant life, no algal forms being present and no grasses or other pioneer plant species finding a foothold until the reef has attained to the prominence of a sand island with some portion definitely and permanently above water. On the living reef, certain green and brown algae are sometimes fairly conspicuous, but as a general thing the coral reef may be described as a zoologist's paradise and a botanical desert.

*The Living Reef:*

A misapprehension, which seems to be common in connection with living coral, is that the coral grows in great profusion, even forest-like, over the ocean bottom. While it is certain that there must be great variation in the thickness of the coral growth in different waters, on the Florida reefs, the writer has never seen any growths that approximated the appearance of a forest. Rather, the coral growths, seen by the author, call to mind the desert, where the sage and chaparral grow sparsely, with definite interspacing areas of bare sand. In this connection it may be well to point out that the immaculately white, glistening coral sand is, perhaps, after all, the most startling feature of the coral reef regions. The whiteness of coral sand is almost unbelievable, relegating the New England housewife's kitchen floor, on Saturday morning, to a bad second in the competition for spotless cleanliness. This pure white sand furnishes a wonderful background for the vari-colored life, which flashes above it, for again it is not the coral which gives color to the coral reef,

but rather is this feature due to the other animals which live and grow in and about, the dull yellowish clumps of coral. In the seas where red coral grows, the coral itself may add to the color of the reef. On our own reefs, however, no red coral is found.

Imagine, then, the living coral reef as a rolling plain of pure, spotless white sand from which there grows a scattered shrubbery of soft, gracefully waving, yellow, red and purple sea plumes. Surrounded by, but frequently extending above the sea-plume shrubbery are the rigid, bush and tree-like growths of yellowish coral, while a multiplicity and never-ending variety of brilliantly colored and patterned small fishes gives life to an otherwise almost too placid panorama. The atmosphere of the living coral

ELEPHANT'S EAR SPONGES.

seascape, as seen through the mirror-like transparency of the crystal-clear sea water, on a windless day, is one of calm, undisturbed meditation which it would appear no storm could ever ruffle. This appearance of permanent peacefulness quickly becomes one of turmoil, however, with the arrival of a school of predaceous fish or with the "blowing-up" of the never-ending trade winds which sweep the waters of the tropical seas.

Since the coral animals can thrive only where oxygen and food are plentiful, they must be looked for where the water is active, which means outside the coral reef or in the channels that the currents and waves have maintained, through the dead barrier reef. In these regions of actively flowing water, the coral colonies will be seen projecting up from the white sand. Along the sides of the channel, for example, great palmate or moose-horn growths may reach to a height of ten feet or more and a diameter of half this distance. A little to one side of these giant colonies may occur low clusters or bush-like colonies of deer-horn or big-finger coral, while in the swifter water of mid-channel there will likely be seen scattered clusters of little-finger coral, these latter

appearing, at times, at regularly spaced intervals as though laid out and planted by some marine gardener.

Outside the dead barrier reef, there grow, in addition to the forms already mentioned, great masses of brain coral, several feet in diameter, and weighing many tons. These gigantic coral growths find a foundation on the strata of dead coral rock which form the seaward approach to the barrier reef. This coral foundation is apparently made up of flattened slabs and ledges that do not agree in shape with any living coral and thus it seems evident that their formation is the result of pressure together with a cementing action by the sea water, of the finer coral particles, that are being constantly produced, by the grinding action of the waves.

The most conspicuous animals, other than the corals, in the living reef, are the sea-fans and sea-plumes. These plant-like animals, of the genus *Gorgonia*, give to the otherwise frozen reef, graceful motion and delicate coloring. The sea-plumes are especially noticeable, growing up as they do to a distance of from one to four feet from the white sand, as delicate multi-colored plumes of orange, purple, yellow and red, which wave gently back and forth, under the influence of the ocean swell that passes above, too far to injure, but near enough to agitate the delicate branches.

Then there are the fishes! Just why the fishes of the coral reefs should have acquired their brilliant, bizarre patterns is a puzzle to naturalists. To the human eye these primitive patterns of red against yellow, orange on blue, etc., are certainly of no value as camouflage, for the Pork fish, the Angel fish, the Parrot fish and the other astonishingly bright-patterned species, associated with the coral reefs, are among the most conspicuous of all animal species, especially when seen, as they usually are, against the indescribable whiteness of the immaculate coral sand. These brilliant fish, as a matter of fact, might be said to realize the natural danger of too much contrast in color pattern, for they seem always to keep close to the protecting fortresses of jagged coral, into whose miniature caverns and mazes they instantly lose themselves when danger threatens in the form of a cruising Barracuda, Mackerel or other carnivorous ocean inhabitant. The fish of the frozen coral caverns share their homes to some extent, however, with the aggressive, ugly dispositioned morays which yellowish-brown, ell-like fish may be seen lying on the white sand, at the base of the brain corals, their evil jaws work-

ing slowly as they pump fresh water through their gills. Likely, the morays feed on the fish of the reef, although in the daytime, the brightly colored fish swim back and forth over the easily distinguished morays, with no apparent notice being exhibited upon the part of either form.

Finally, within the coral cluster, or colony, there exists an all but invisible association of small sea animals, including many species of other phyla such as the Sponges, Crustacea, Worms and Molluscs. If, for example, one hauls to the surface a clump of little finger coral and begins to break it up, he exposes to view a veritable Babylonian army of frantically hopping, swimming, flopping, crawling amphipods, worms, tiny fish, crabs, etc., until he is likely to become completely bewildered by the confusion of species and number of individuals that he finds in so limited a habitat.

After all is said, the coral reef is the coral reef and no pen has yet done it justice. To appreciate its wonders, one must visit the reef for himself. A single visit will open up a new field of speculation at the complexity and marvelousness of life. A second visit will but lead to a third, from which time on future trips to the coral reef for investigation and pleasure will be limited only by the resources at hand, for it soon becomes clear that no one may, even in a lifetime, unravel the secrets of the coral reef.

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## BREEDING CAGES FOR INSECTS.

One of the most interesting phases of insect study is the rearing of insects. The simplest way is to collect the cocoons, attached to various trees in the fall, and the moths, red, brown, or pea green, will appear the following spring. It is more instructive, however, to collect the larvae or caterpillars and place them in a box where they can be supplied each day with the proper kind of leaves for food. By this means one can watch the caterpillars change their skins while they grow, and also note the change from the caterpillar to the pupa or chrysalis. The last larvel skin shed by the insect larva on pupating and the pupal skin should be saved, together with the adult that issues from it. Any box with a top of netting to prevent the caterpillars from getting out will be suitable. By putting moist sand in the bottom of the box, the food will keep fresh a longer time.

A very convenient and useful breeding cage is made by putting a lamp chimney in a flowerpot, the top of the chimney covered with a piece of gauze or mosquito netting. If the pot rests in a saucer containing water the sand or earth in the pot can be kept moist so that the twigs of the food plant will remain fresh for some time.—*Margaret C. Mansuy in U. S. Department of Agriculture, Farmers' Bulletin No. 1601.*

# HOW THE SCIENTIST GOES ABOUT IT TO FIND PETROLEUM.

By Chas. N. Gould,

*Director, Oklahoma Geological Survey, Norman, Okla.*

## Part II.

In a previous paper I discussed the four essentials of an oil field, namely, source of supply, reservoir rock, cap rock, and structure. I also attempted to show by two homely illustrations, namely, oil, gas, and water in a bottle, and a coin under a table cloth, how oil occurs and how structures may be located. In this article I am outlining the various methods used by scientists in helping the oil man locate oil.

### The First Oil Well

The first wells in the United States which produced oil were not primarily oil wells at all, but were wells drilled for salt brine. Oil, a waste product from brine wells, was refined at Pittsburgh and Tarenton, Pennsylvania, as early as 1842-43. The only products saved were kerosene and medicinal oil.

In 1859 Col. E. L. Drake drilled a well for oil near Titusville, Pennsylvania, and on August 28 of that year the first oil well came in. At this time rock oil was selling for $25.00 and $30.00 a barrel. During the 70 years between 1859 and 1929 almost each year has seen the total amount of oil production increase over the year before, until today the production of oil in the United States totals around 900 million barrels per year.

During the first few decades of the oil industry wells were located in a haphazard manner without scientific advice. Men played hunches. Oil wizards with crooked sticks, or some mysterious methods were frequently used to locate oil wells. An operator of the old school once told me that his method of locating an oil well was to tie a tin can to a dog's tail and start the dog off across the country. Where the tin can came off there he would drill his well. And these methods were sometimes successful in locating oil. It has been estimated that one well out of fifty located by these unscientific methods really produced petroleum just as one would have perhaps one chance in fifty of hitting the coin under the table cloth.

### Anticlinal Theory

During the eighteen eighties and eighteen nineties scientific methods for locating oil were first used. The anticlinal theory

of oil accumulation, which I have already attempted to describe very briefly in a former paper, was first successfully employed. Several men working independently seem to have arrived at the elements of this theory theory at about the same time, but it was Dr. I. C. White, State Geologist of West Virginia, who first successfully used anticlinal methods in locating oil.

However, the thing was a matter of slow growth. For several years geologists themselves were not sympathetic toward Doctor White and his theories. The oil men scouted the idea and continued to use doodle-bugs, magic rods, hunches, and tin cans tied to dogs' tails. It was not until the first decade of the present century that geological methods were used to any considerable extent. During these years geologists were treated as a sort of mild freak or as the typical absent-minded professor. And it was not until these men had demonstrated over and over again, times without number, that they were really able to save the oil man money that the science of geology came into its own in the matter of oil finding.

I think I am safe in making the statement that never in the history of any industry has there been such a complete revision, or right-about-face, and change of front, of public opinion as has been experienced in the attitude of the oil man toward the scientist during the past two decades. Today, all the larger oil companies employ a scientific staff. Geologists, engineers, chemists, paleontologists, petrologists, physicists, geophysicists, and geothermal men are in the employ of most of these large companies. Laboratories are maintained, experiments are constantly going forward, examinations are being made of this, that, and the other thing, in the endeavor to find more and more oil, so that today thousands of young men and women are carving out a career and making a livelihood along scientific lines in assisting oil men to put barrels of oil in the tank. And it is the methods employed by these various scientists, in the continuous, never-ceasing search for oil, that I am discussing with you at this time.

## Natural Phenomena.

The first method for finding oil, used alike by the oil man and by the geologist, and still used in certain instances, was the observation of natural phenomena, such as asphalt seeps, oil springs, and gas vents. Asphalt, or pitch, has been used for untold generations. Noah's ark was daubed with pitch, or

asphalt, within and without, and Moses' cradle of bullrushes among the reeds of the River Nile was lined with pitch. And it is interesting to note that Assyrian and Egyptian asphalts are still on the market. One of the most interesting phenomena which has come to my attention is on the shores of the Caspian Sea. One of the most noted of ancient shrines of the fire-worshipers of the Zoroastrian religion, was located at this place, where burned the eternal fires. Science has demonstrated that the "eternal fires" were nothing but a gas vent on the axis of an anticline. This is now known as the Baku anticline, and the great Baku oil field of Russia on the Caspian Sea now surrounds this original gas vent and where may still be seen the ruins of the Zoroastrian Temple.

## Reconnaissance.

The second method for locating oil, and really the first scientific attempt along this line, is one which in many cases is still practiced by geologists. It is usually known as the reconnaissance method. The geologist provides himself with three simple hand instruments; the aneroid barometer for taking elevations, the Brunton compass for observing dips, and the Locke level with which he can take a sight on some distant point and determine whether it is higher or lower than his present position. With these instruments in his pocket the geologist walks or rides across the country looking for outcrops of rock ledges. If he finds, as he often does, a ledge of rock dipping in two directions from a certain point, something like the roof of a house, he knows that he has located an anticline. One might ride or tramp weeks in a region without finding any surface indications that look favorable. But having found indications of an anticline, the geologist often spends a number of days tramping out the region and locating the axis of the anticline. The land will then be leased and a well drilled. Many of the earlier oil fields in the United States have been located in this manner.

## Plane Table.

The third method for locating anticlines and the one which has been used more than any other single method, and perhaps more than all other methods combined, is known as the plane table or alidade method. The use of this method includes a knowledge of civil engineering as well as geology. Two men go into a country, one carrying a 12-foot rod, the other with a

plane table on a tripod, and a surveying instrument known as a telescopic alidade. The object is to trace out and map the outcrop on the surface of a certain ledge, or series of ledges, in an endeavor to find an anticline or a dome. Very often this method is combined with the reconnaissance method which I have just described. The reconnaissance man with his simple hand instruments will locate a structure, then the alidade party will follow and prepare the contour map. This map shows by contour lines the "highs," or anticlines, and the "lows" as indicated by the position of surface ledges in the region surveyed. It is on the basis of contour maps that most wells are located.

This method was first employed in the Mid-Continent oil field about 1912, and at the present time there are hundreds of parties throughout half-a-dozen states in the Mississippi Valley engaged in contour mapping with the plane table and alidade. In certain parts of Kansas, Oklahoma, and Texas, there is scarcely a section of land that has not been mapped, often scores of times, by the geologists of various oil companies. And this method of hunting structure has never been superseded, and probably never will be, for general geological work. But it can be used only in those regions where ledges of rock outcrop on the surface. To give an example of the extent of this work, a single oil company recently undertook the surface contour mapping of an area in west Texas almost as large as the State of New York. Scores of parties were put to work in dozens of counties, and this work was continued for several years. Data of this kind which have been collected and compiled are now resting in the confidential files of many a large oil company with headquarters at Houston, Dallas, Tulsa, or New York, and much of this information, being confidential, will probably never be released to the public.

### Subsurface Geology.

A fourth method which follows closely in the steps of the surface work which I have described is known as subsurface geology or the determination of structure from logs of deep wells. More and more each year the driller is keeping better and more accurate records of the wells that have been drilled. In many states, the law requires that copies of each of these well logs be submitted to some state organization, in Oklahoma it is the Corporation Commission. Anyone wishing these logs may secure them by paying a very nominal fee for copying. These logs are collected, plotted in color on long strips of paper, and

by the study of these logs, subsurface conditions are determined. It has been found that in many cases there are anticlines or domes beneath the surface that do not show at all in the surface rocks.

Each of the larger oil companies now has what is known as the subsurface department. When a series of wells have been drilled in a certain region, elevations are run to the mouths of the wells, the logs are secured, and skilled men and women in the subsurface department plot these logs in color, and by means of careful study and comparison of these logs they are often able to determine structure beneath the surface which does not appear otherwise. This is one of the departments where women graduates of schools of geology are profitably employed.

### Core Drilling.

A fifth method used for determining oil structures is known as core drilling. In many places there are no surface ledges which will give a geologist a clue to underground conditions. On the flat plains of western Kansas, Texas, and Oklahoma, there are few surface rocks. In the glaciated areas of Illinois, Michigan, and Ohio, bed rocks rarely reach the surface. In many regions, as for instance river valleys, deposits of loose rock or alluvium have blanketed the bed rock. This being true, other methods must be sought for determining structural conditions. That is to say, some other way must be found for locating anticlines or domes. One of the favorite methods used is core drilling. By this method, shallow wells, usually only a few hundred feet deep, and relatively inexpensive to drill, are put down at regular intervals throughout the country. The object of this core drilling is not to find oil but to find beneath the surface some definite ledge upon which subsurface structures may be worked out. This is usually a ledge of limestone or perhaps a bed of red clay, in fact, almost any datum of ready reference. During the past few years it has been a common thing in certain parts of Kansas and Oklahoma to find the small core drilling machines busy at work drilling shallow holes in the farmers' fields in order to determine what may be found beneath the surface, and several of the larger producing fields in the Mid-Continent area have been discovered in this way.

As more and more of the easy work has been accomplished, and the greater number of the fields determinable by surface methods have been located, the oil man has been obliged to resort to some other method for finding anticlines and core

drilling is in many ways the cheapest and most efficient method that has been devised.

### Paleontology.

A sixth method is by means of fossils. Fossils are the geologist's clock, the manner by which he tells geologic time. Studies by many men in many lands for the past 125 years have shown that no two geologic ages contain the same kind of fossils. It was James Hall, the noted New York geologist, who once said, "You may blindfold me and take me to any part of New York you choose, then turn me loose and give me time to find a fossil in the rocks and I will tell you, if not the exact county, at least the part of the State I am in." And so geologists and paleontologists by studying these fossil animals and plants from all parts of the world can identify with great accuracy the different geologic formations. The fossils found in the rocks at the bottom of a well always differ from the fossils in the upper horizons. So that by a study of the fossils brought up from thousands of feet below the surface, the geologist can often identify the particular formation in which the drill is working.

The great trouble is, however, that the bit, in pounding its way downward from the surface, crushes and mangles the fossil shells until they are usually macerated and ground into powder so that they are scarcely recognizable. There is, however, a type of fossil not easily injured by the drill, and that is the little fellows, or as the paleontologist would call them, the micro-fossils—the microscopic forms often too small to be distinguished by the naked eye. If the drill cuttings are saved from any particular formation beneath the surface, and turned over to the micro-paleontologist he can often tell by examining these tiny forms under the microscope just where in the geologic column they belong, and knowing the formation in which the oil may be expected in this particular well, he can often tell by the study of these micro-fossils whether or not it will be necessary to drill deeper to find this oil. By this method, thousands of dollars are often saved by the oil man.

Most of the larger oil companies now have a micro-paleontological staff, and these scientists are busy day after day examining specimens sent from all parts of the country. This again is a department where trained women paleontologists are very efficient.

### Heavy Minerals.

A method somewhat similar to the study of micro-fossils is

that of the study of heavy minerals. Sandstone is made up of grains of sand cemented together, and sand grains consist of small fragments of mineral of various kinds, the most abundant of which are grains of silica or quartz. But in addition to quartz one finds in most sandstones grains composed of very many other minerals. Now geologists have learned that certain minerals predominate in certain sands. One sandstone may contain an abundance of fragments of tourmaline, another of quartz, another of zircon, and still others may contain other minerals in varying amounts. So that the geologist and petrographer by studying the grains of sand brought up from thousands of feet beneath the surface may often be able to determine with considerable certainty just what ledge the drill is penetrating. If both micro-fossils and certain types of heavy minerals are present the evidence is just that much more conclusive, but in case the fossils are not present, as sometimes happens, identification may often be made on heavy minerals alone. This is another specialized science where women are efficient, and today several women in Oklahoma are recognized as being the leaders in this particular line.

### Brine Analysis.

A method used by a number of the oil companies is that of analysis of deep well brines. Most deep wells encounter salt water, but it so happens that while the water from a single stratum will show practically the same chemical content over wide areas, water from different strata usually show different contents. Or to say it differently, no two brines from different beds ever analyze exactly the same. Recognizing this fact, many of the larger companies collect the brines from each stratum, if any are present, and have them analyzed, and by so doing are often able to determine with much certainty the correlation of the various beds.

### Geophysical Instruments.

A new method, or perhaps one should say a series of new methods, for the location of possible subsurface structure has come into general use in the oil fields within the past three or four years. I am now referring to the use of so-called geophysical instruments.

There is a popular notion that these geophysical instruments are used for finding oil. This is a mistake. No instrument known to man will locate oil beneath the surface. Literally

hundreds, perhaps thousands of instruments of this kind have been tried without success. These are the ordinary doodle-bug, forked-stick instruments used either by ignorant men or by fakers, usually designed to catch the unwary. The geophysical instruments to which I am now referring are *bona fide* scientific mechanisms, designed chiefly by eminent physicists and mechanics. They are used, not to find oil but to attempt to find buried anticlines or domes, which sometimes may contain oil.

There are four classes of these instruments in common use today; namely, the torsion balance, the seismograph, the magnetometer, and the gravity pendulum.

### The Torsion Balance.

This is a device for measuring the rate of change of the minute gravitational forces caused by hidden masses of higher or lower density. The data brings out the maximum horizontal variation in gravity and the direction of no change in gravity.

### The Seismograph.

The seismograph is a device for receiving and recording artificial earthquake waves, thereby determining local variation in the rate of passage of waves through the earth's strata. The data is secured on the principle that the speed of transmission is different for formations of different physical proportions.

### Magnetometer.

This is an instrument used for measuring the components of the earth's magnetic field. By comparing readings at different locations, variations in the earth's magnetic field can be detected for formations that have abnormal magnetic properties, for instance, masses of igneous rocks, etc. In field practice the vertical component is usually measured.

### Gravity Pendulum.

The gravity pendulum is a specially designed time-piece which records the local variations in density of the subsurface forces in terms of differences of gravity.

Time will not permit me to go into greater detail regarding the workings of these various instruments. It is extremely difficult, not to say impossible, to attempt to explain in a sentence or two the highly technical operation of these very delicate pieces of mechanism, and for that reason, I shall omit all discussion of the technique of the subject. However, let me cite a specific example, showing how these instruments have proved

successful. Practically all the oil found along the Gulf Coast of Texas and Louisiana occurs under peculiar forms of structure known as *salt domes*, of which Spindletop, near Beaumont, is the outstanding example. Sometimes these domes can be determined from the surface. Often they can not. It is stated that during thirty years exploration up to 1921, 38 salt domes had been found by surface indications. Since 1921, 35 additional salt domes have been discovered by the use of geophysical methods. It is estimated that since 1921 over seven million dollars have been spent by the various oil companies on geophysical methods on the Gulf Coast alone.

### Deep Well Temperatures.

Another method and one which is now being tried out in but few places is known as the geothermal gradient method; in other words, the determination of underground temperatures in deep wells. We were taught in our school geographies that the temperature of the earth increased downward about one degree for every 63 feet beneath the surface. Experiments now being carried on in three states, California, Texas, and Oklahoma, under the direction of the National Research Council and financed by the American Petroleum Institute, show that as a usual thing the increase of subsurface temperature is much more rapid on geologic structure than under ordinary conditions. On some of the salt domes of Texas, for instance, the temperature increases one degree for every 20 feet. Just what this may mean we do not know. It is one of the problems which must be solved by careful, systematic investigation through a period of years, but many believe that once the problem has been solved, the method of the testing of deep well temperatures will have its place in oil-finding.

### Ceramics.

About the last thing over the horizon, and one which is being used to a very limited extent, is what is known as the ceramics method. It is based on the theory that no two clays will burn the same color in the same temperature, and at the same time no two clays have exactly similar colloidal qualities. So that if there are no micro-fossils in a well, and the identification of heavy minerals do not help solve the correlation problems, and if analysis of salt brines do not aid, it is sometimes possible by making burning and colloidal tests on the clays to determine the geologic horizons. This is another problem not yet solved but which in time bids fair to help in oil finding.

In the third and last paper of this series I hope to answer the question that is always asked, does the geologist really find oil? and to show that by the use of these methods the scientist really *does* help the oil man.

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## TIME ALLOTMENTS IN PLANE GEOMETRY.

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In the published courses of study and lists of objectives in geometry there is seldom much information about how much time should be allotted to each of the units. As a start toward the collection of such information I am presenting an outline of the first semester's work in an average class in Plane Geometry dividing the work into 80 lessons. A later paper will outline the work for the second semester.

The outline is the result of twelve years experience in teaching 29 classes in plane geometry averaging 39 pupils per class. The outline was made by keeping a careful record in eight of the classes of what was accomplished each day. In a notebook I recorded how many minutes were spent by some pupil in presenting a proof of a theorem, what exercises were worked and how many minutes were spent on each one. The making of such a record is not so laborious as it might seem. During the period in class I had merely to make such notations as

9:05, Ex. 60. 9:08, Ex. 61. 9:15, Th. 14. 9:20, §123.

Further, I was aided at various times by having a stenographer in the class to record every word spoken during the period by teacher or pupils. The stenographer also kept a record in the margin of her notes of the lapse of time minute by minute.

After a few semesters I found many places where time could be saved because I could anticipate certain difficulties and prepare for them. I learned, as every teacher does, that certain exercises were the best ones for illustrating a certain theorem. I could avoid an exercise which might illustrate the theorem well enough but which would introduce some irrelevant feature or cause worthless digressions. In many places I could select not merely a good exercise but one which would prepare the pupil for a subsequent theorem, thereby accomplishing several objects at once. If a certain item was not to be used for fifteen or twenty days I postponed treating it until it could be used.

In the following outline some of the lessons actually occured in two parts. The first meeting of the class, for example, may be

long enough only to tell the pupils what materials to get. A fire drill or some assembly might reduce the usual forty minutes to thirty minutes. But each lesson below covers forty minutes of time in class. Further, it is not possible in a brief outline to state in each lesson how many minutes were spent in preparing the class for the next day's assignment. Since the main object of this outline is to show the amount of time devoted to each unit, only the central idea of each lesson is stated. Supplementary work done by above-average pupils is not mentioned.

INTRODUCTION. LESSONS 1 TO 11.

**1.** An assignment of some reading to be done at home is not sufficiently concrete for the lazy pupil. To encourage a habit of industry as soon as possible, I begin by teaching the fundamental constructions. The first 40 minutes is devoted to learning how to copy an angle, how to read the name of an angle, and how to add and subtract adjacent angles.

**2.** How to bisect an angle. Definition of perpendicular and of right angles. How to construct a perpendicular to a line through a point on the line.

**3.** How to construct a perpendicular to a line through a point not on the line.

**4.** How to construct a perpendicular bisector of a line. Complementary and Supplementary angles.

**5.** Exercises which review these five constructions and the work on angles.

**6.** Complements of the same angle are equal. Supplements of the same angle are equal.

**7.** Vertical angles are equal. The meaning and use of a general statement. Give a test for 15 minutes in which the pupil is asked merely to perform certain constructions.

**8.** Construct a triangle given two sides and the included angle, or two angles and the included side, or three sides.

**9.** The difference between experimental (or intuitive) geometry and demonstrative geometry. To give the pupil some concrete work to do at home I assign some exercises on constructions or some geometrical drawings.

**10.** The fundamental axioms; exercises based on the axioms.

**11.** What a Theorem is. How to select the hypothesis and conclusion. Reading (without giving proofs) of the usual fundamental theorems like: All straight angles are equal; all right angles are equal, etc.

BOOK I. LESSONS 12 TO 60.

**12.** Th. 1. If two sides and the included angle of one triangle are equal, respectively, to two sides and the included angle of another triangle, the triangles are congruent. Discuss the meaning of the theorem. Do not expect pupils to recite it at the board. Discuss how the theorem is used.

**13, 14.** Exercises based on Th. 1.

**15.** Th. 2. If two angles and the included side of one triangle are equal, respectively, to two angles and the included side of another triangle, the triangles are congruent. Again place the emphasis on knowing how to use the general statement and not on being able to recite the superposition proof.

**16.** Exercises based on Th. 1 and Th. 2. The pupil's work is considered satisfactory if he can state what three parts of one triangle are equal to three parts of the other triangle.

**17.** Exercises in which the pupil proves two triangles congruent and then adds one more step to prove certain lines or angles are equal. Give a test for 15 minutes asking the pupil to construct the figure and prove two triangles congruent. In the early tests I frequently use an exercise which the class has just finished working. This stimulates attention in class and enables me to select the pupils who do not give attention in class.

**18.** Th. 3. The angles opposite equal sides of a triangle are equal. This is the first theorem which pupils can be expected to recite completely at the blackboard. But always the emphasis is placed on how a theorem can be applied to exercises. Do at least one exercise using the theorem.

**19.** Exercises based on Th. 3.

**20.** Exercises. A 15 minute test. Discuss Th. 4 as a preparation for the next day's work.

**21.** Th. 4. If the sides of one triangle are equal respectively to the sides of another, the triangles are congruent.

**22.** Th. 5. If two points are each equidistant from the ends of a line, they determine the perpendicular bisector of the line.

Hereafter I begin each day's work with a 3 or 4 minute oral quiz, asking such questions as:

What are the three ways of proving triangles congruent?

What important fact have we proved about isosceles triangles?

How do we use triangles to prove lines or angles equal?

**23.** The five fundamental constructions proved by congruent triangles. A pupil can go to the board, bisect an angle with compasses, and prove the two parts equal in about six minutes.

**24.** Definition and construction of altitudes and medians of a triangle. Exercises.

**25.** General review and test. The pupil's work is considered satisfactory if he can perform slight variations of the five fundamental constructions and do exercises in which he must prove two triangles congruent.

**26.** Th. 6. An exterior angle of a triangle is greater than either of the remote interior angles.

**27.** Angles associated with two lines and a transversal. Discussion of what an indirect proof is. Do not assign the next theorem for homework (its discussion should begin in class), but assign some review work.

**28.** Th. 7. If two lines intersect a third line so that a pair of alternate interior angles are equal, the two lines are parallel.

Whether pupils can recite the proof at the board is immaterial provided they learn how to use the theorem. Work a few simple exercises in which lines are proved parallel by using the theorem.

**29.** Corollaries of Th. 7. How to construct a line through a point and parallel to a given line. To the oral quiz mentioned in Lesson 22 add the question:

What are three ways in which lines can be proved parallel?

**30.** Exercises. Discussion of what a converse of a theorem is.

**31.** Th. 8. If two lines are parallel, the alternate interior angles formed by a transversal are equal. Corollaries.

**32, 33.** Exercises based on parallel lines and congruent triangles. On each of these days give a test of 15 minutes. The exercises should be so simple that only the very poorest 8% or 10% of the class can fail. The first tests in any subject should be so easy that the pupil forms the habit of succeeding.

**34.** Th. 9. The sum of the angles of a triangle is 180°. Corollaries.

**35.** Exercises.

**36.** Th. 10. Two right triangles are congruent if the hypotenuse and an arm of one equal respectively the hypotenuse an arm of the other.

**37.** Th. 11. If two angles of a triangle are equal, the sides opposite those angles are equal.

**38.** Th. 12. If a point is on the perpendicular bisector of a line, the point is equidistant from the ends of the line. The converse.

**39.** Th. 13. If a point is on the bisector of an angle, the point is equidistant from the sides of the angle. The converse.

**40.** Exercise based on Th. 12 and Th. 13.

**41.** Exercises reviewing this unit. A 15 minute test.

This would be the proper place to study:

Th. 14. If two angles have their sides respectively parallel, the angles are either equal or supplementary.

Th. 15. If two angles have their sides respectively perpendicular, the angles are either equal or supplementary.

Both of these theorems are required by the College Entrance Examination Board; neither statement is worth being called a theorem. Any exercise that can be proved by using these theorems can be proved just as easily in some other way.

**42.** Th. 16. The opposite sides, and the opposite angles of a parallelogram are equal. Corollaries.

**43.** Th. 17. The diagonals of a parallelogram bisect each other.

**44.** Th. 18. If the opposite sides of a quadrilateral are equal, the figure is a parallelogram.

Th. 19. If two side of a quadrilateral are parallel and are also equal, the figure is a parallelogram.

**45.** Th. 20. If the diagonals of a quadrilateral bisect each other, the figure is a parallelogram. A 15 minute test on parallelograms.

**46.** Special parallelograms: Rectangle, Rhombus, Square. The trapezoid.

Some explanation is needed here concerning the apparent very rapid treatment of parallelograms. The reader will have noticed that the introduction, Lessons 1 to 11, is also rather brief. This is so because all the emphasis during the first two months is placed on the use of congruent triangles. As shown in Lessons 12 to 15, the first two congruence theorems are practically assumed, there being only enough discussion about the statements to enable the pupil to grasp their meaning. The pupil is not called on to recite at the board the proofs of Theorems 1, 2, 6, 7, or 8. He needs to know merely their use. The other theorems are sufficiently direct in proof so that the pupil can present them. The emphasis is on exercises. Hence when the pupil reaches Th. 12 or Th. 13 he has already worked them as original exercises since they involve only proving two triangles congruent. Likewise, when studying parallel lines, the pupil has worked as exercises all the theorems about parallelograms. The wise teacher will have used the same exercises again and again disguised in various forms.

When the unit on parallelograms is reached it is necessary merely to recognize the statements as theorems and to summarize the acquired knowledge under two headings:

(a) Facts we have learned about parallelograms.

(b) Four ways of proving that some quadrilateral is a parallelogram.

The oral review at the beginning of each period hereafter includes questions about parallelograms.

**47.** Half of the period is devoted to trapezoids and half to an analysis of the next theorem.

**48.** Th. 21. If three or more parallels cut off equal segments on one transversal, they cut off equal segments on any transversal. Corollaries.

**49.** Th. 21 repeated, and proved several times. How to divide a line into *n* equal parts.

**50.** Th. 22. If a line joins the mid-points of two sides of a triangle, it is parallel to the third side and equals half of it.

This theorem is omitted from the list of the College Entrance Examination Board; in many ways it is one of the most interesting and useful theorems in Book I. Every pupil gets a thrill from using this theorem to prove: In any quadrilateral the lines joining the mid-points of consecutive sides form a parallelogram. The theorem is also very useful as an introduction to the topic of auxiliary lines. This theorem should be included even if some other work must be sacrificed.

**51.** Discussion of auxiliary lines, synthetic and analytic proofs.

**52, 53.** Exercises. Review. Test.

**54.** Th. 23. The sum of the angles of a polygon of n sides is (n—2) 180°. This theorem could be postponed until Book V is reached as it is not used till then. The theorem is quite popular among teachers who talk about teaching geometry inductively. Unfortunately there are few other theorems which can also be taught inductively to any advantage; hence after the teacher has preached the inductive method he finds he is short of material on which to practise his preachings. Since the theorem is comparatively unimportant (in the sense that there are few exercises to which the pupil can apply it) it deserves hardly twenty minutes of class-time. The remainder of the period is used to introduce the next topic.

**55.** The Inequality Axioms.

**56.** Th. 24. If two angles of a triangle are unequal, the sides opposite these angles are unequal, and the greater side is opposite the greater angle.

Th. 25. If two sides of a trinagle are unequal, the angles opposite the sides are unequal, and the greater angle is opposite the greater side.

**57.** There are two more theorems, 26 and 27, about unequal sides and angles. It is useful for the pupil to see that not all the theorems of geometry deal with equal quantities. In a minimum course, however, it is inadvisable to spend more than three days on the topic of inequalities. If the class is behind its schedule, just a single day is spent on inequalities.

**58.** Th. 28. The bisectors of the angles of a triangle are concurrent at a point that is equidistant from the sides of the triangle.

**59.** Th. 29. The perpendicular bisectors of the sides of a triangle are concurrent at a point that is equidistant from the vertices of the triangle.

Theorems 28 and 29 are useful because their proofs involve the use of certain theorems, 12 and 13, and the converses of 12 and 13. The opportunity is here taken to discuss "converses" carefully. All pupils will not grasp the ideas the first time, and hence the ideas must be reviewed whenever the opportunity arises.

**60.** Th. 30. The altitudes of a triangle, or their prolongations, are concurrent.

Th. 31. The medians of a triangle are concurrent at a point that is twice as far from any vertex as from the mid-point of the opposite side.

Few pupils will remember the clever proofs of these theorems very long, and a slow class may be satisfied merely to read the theorems and construct the figures. Most pupils have little difficulty with Th. 31 if the proper emphasis has been placed on Th. 22; in fact, Th. 31 can be worked as an exercise when Th. 22 is studied. Since Th. 31 has more applications in later work than Th. 30, the emphasis should be placed on the former.

### Book II. Lessons 61 to 80.

**61.** Part of the period is devoted to introducing Book II, and part to a review or test on Theorems 28 and 29.

**62.** Th. 1. Equal central angles, in the same circle or in equal circles, have equal arcs and equal chords.

Th. 2. Equal chords, in the same circle or in equal circles, have equal central angles and equal arcs.

Th. 3. Equal arcs, in the same circle or in equal circles, have equal central angles and equal chords.

When the proof involves only two congruent triangles, the pupil is expected to give the proof. In the other cases it is sufficient to read the proof in the text. In a minimum course there is not time for the theorems about unequal arcs and angles.

**63.** Exercises based on Th. 1, 2, and 3.

**64.** Th. 4. A line through the center of a circle perpendicular to a chord bisects the chord and the arcs of that chord. Corollaries.

**65.** Th. 5. Equal chords, in the same circle or in equal circles, are equally distant from the center.

Th. 6. In the same circle or in equal circles, chords equally distant from the center are equal.

Since both of these theorems involve only proving that some triangles are congruent, the work can be done in one day. In fact, when choosing exercises to which to apply Th. 4 the teacher should choose such exercises as prepare for Th. 5 and 6. Theorems 4, 5, and 6 can then be done in one day.

Theorems 7 and 8, dealing with unequal chords and unequal distances from the center, can be omitted in a minimum course, or a single day (if time allows) devoted to them.

**66, 67.** Th. 9. If a line is perpendicular to a radius at its outer extremity the line is tangent to the circle.

Th. 10. If a line is a tangent, then it is perpendicular to the radius drawn to the point of contact. Corollaries.

The method for constructing a tangent to a circle through a point on the circle, and through a point not on the circle.

The proofs of the theorems are read from the book and discussed. No time is spent in asking pupils to come to the board and present the proof. The emphasis, as previously mentioned, is on the ability to apply the theorems to exercises.

**68.** Inscribe a circle in a triangle. Circumscribe a circle about a triangle. While these constructions are usually treated later, they should be treated at this point because many exercises are based on inscribed and circumscribed figures.

**69.** Th. 11. Tangents to a circle from a point are equal.

Give a test on the work of the previous week.

**70.** Exercises based on Th. 11.

**71.** Th. 12. If two circles intersect, the line of centers is the perpendicular bisector of the common chord.

Th. 13. If two circles are tangent to each other, the line of centers passes through the point of contact.

**72.** Review of Book II.

**73.** Begin the measurements of arcs and angles.

Th. 14. The number of degrees in a central angle is the same as the number of degrees in its arc.

**74.** Th. 15. An inscribed angle is half as large as the central angle that has the same arc. Corollaries.

**75.** The teacher should emphasize the fact that whenever we wish to find out how an angle is measured, the general plan is to draw some helping line that will make some inscribed angles in the figure. As an illustration of this method the teacher can draw the figure for Th. 16 on the board (without mentioning that there is such a theorem) and ask "What line shall I draw in order to form some inscribed angles? How is the angle between the tangent and the chord related to the inscribed angle?" Again as an illustration of Th. 15, the teacher can draw two parallel chords or two secants and ask the same questions. In this manner the class can prove as exercises all the theorems belonging to this unit. One day should be spent in hearing pupils recite the proof of Th. 15; the proof should be presented three or four times. The next day can be spent on the work suggested above. The theorems can then be assigned one at a time and reviewed each day.

**76.** Th. 16. The angle formed by a tangent and a chord drawn to the point of contact is measured by one half its arc. Exercises.

**77.** Th. 17. Arcs of a circle between parallel chords are equal. Exercises.

**78.** Th. 18. An angle formed by two chords intersecting inside a circle is measured by one half the sum of the two intercepted arcs. Exercises. Test.

**79.** Th. 19. An angle formed by two secants intersecting outside a circle is measured by one half the difference of the intercepted arcs.

**80.** General Review. If the work on angles is treated as suggested in Lesson 75, half of each of the Lessons 76 to 79 can also be used for a general review. This is equivalent to spending 5 days on the measurements of angles and 3 days for review work.

The amount of time spent on the various units is then:

| | Lessons | Number of Lessons |
|---|---|---|
| Introduction | 1—11 | 11 |
| Congruent Triangles | 12—25 | 14 |
| Parallel Lines | 26—33 | 8 |
| Angles | 34—41 | 8 |
| Parallelograms | 42—50 | 9 |
| Methods | 51—54 | 4 |
| Inequalities | 55—57 | 3 |
| Concurrent Lines | 58—60 | 3 |
| Angles, Chords, Arcs | 61—65 | 5 |
| Tangents | 66—71 | 6 |
| Measurements of Angles | 73—79 | 5 |
| Review | 72, 76—80 | 4 |

## Discussion by Everett W. Owen,

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The method of arriving at the time allotments is good, and should help teachers to make a more critical observation of their own methods. The introduction is especially fine. A pupil enters a new subject with an initial enthusiasm which should not be dissipated by a long introduction and many definitions. The proper method is to begin with constructions without proofs.

In a few cases too much time is given. Lesson 18 and part of 19 might be combined; also, lessons 38 and 39. Still less time should be given to the theorems about parallelograms. These should be given by pupils without reading the text. My weakest class did this recently and enjoyed it. Any plan that helps them to get rid of some of their inferiority complexes is good. To solve a theorem unaided which the text considers necessary to prove in full has a good effect on the class. The time saved on theorems is, of course, to be used in solving exercises. Many of these could come at the end of the unit where the method is not too readily suggested by the theorems immediately preceding. The article makes a fine point in urging that exercises of importance be used and many irrelevant ones omitted.

A little more time might be included about the importance,

time, and place for teaching definitions and the use of definitions.

In the main, the amount of work covered agrees rather closely with what I have done this semester. It might be well to make some suggestions as to the different methods and time allotments for classes of different abilities. In the better classes the pupils should be expected to demonstrate most of the theorems, even those which this outline relieves them of demonstrating.

Discussion by Edgar S. Leach,
*Evanston High School, Illinois.*

In comparing this outline with my own assignments for the first semester's work I find that I have spent about the same amount of time on each topic with the exception of the work on tangents. I spend only four days on tangents, and devote more time to review at the end of the semester. The first semester's work ends, as shown here, with the measurements of angles.

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## HISTORY OF BIOLOGY IN THE HIGH SCHOOLS OF CHICAGO.

By Worralo Whitney,
*Chicago, Illinois.*

We can reasonably assume that the history of biology in the Chicago high schools is essentially the same as that of other parts of the Middle West if not of the East. This fact, therefore, is our excuse for narrating the history of biology teaching in Chicago. There has been a slow but steady development in the handling of this subject from the beginning, evolutionary in character.

We are dating the beginning of biology in the high schools of Chicago with the introduction of the laboratory, but the subjects of botany and zoology had been taught in the schools for some time before this as class room studies without laboratories. Biology as a laboratory study was introduced into the high schools of Chicago in the year 1892, the year before the World's Fair. A. F. Nightingale was Superintendent of High Schools and Albert G. Lane, Superintendent of Schools. The subject was made a required study in the first year of the curriculum. The planning for the installation of the laboratories in the various high schools and for the course of study in biology was turned over to E. R. Boyer of the Englewood High School. The use of biology as a subject to be taught in colleges and universities was quite new at that time and still more a novelty as a subject in the high school curriculum. Consequently Mr. Boyer had no

high school experience with the subject to help him in installing the course. Professor Martin of Johns Hopkins University was giving one of the first courses in biology given in this country, if not the very first. His course was copied after Huxley whose pupil and assistant he had been. The course consisted of lectures on a series, in evolutionary order, of types of animals and plants representing the principal and most important groups. Laboratory work accompanied these lectures which were very exhaustive but gave little attention to related forms of animals or plants. This, then, was all Mr. Boyer had to guide him in planning the course for biology in the high schools. The laboratories at that time were equipped with tables seating four students, two on each side. The tables were supplied with drawers for the reception of tools and notes.

Under Mr. Boyer's guidance laboratories were installed in the various high schools. The laboratory tables were equipped with four banks of drawers to accommodate successive classes of twenty-five to thirty-five pupils, each with an individual drawer at the tables. Sinks with running water and large lead lined aquaria also with running water were installed in each laboratory. Compound microscopes of Leitz make with sliding tubes for focusing, enough for one microscope to each two pupils, were also provided and a few wall cases for storage of microscopes and other equipment. Thus these were real laboratories such as were used at that time in the best colleges. Microtomes and other equipment needed for exhaustive studies of animals and plants were at hand, not to mention an important factor at that time, the dissecting pans with wax bottoms.

As in the case of the equipment of laboratories Mr. Boyer planned the course of study for biology essentially after the Huxley and Martin course. There was nothing else to guide him and no textbook. He wrote out the lessons, mimeographed them and supplied each teacher with a copy, who, in turn, prepared copies for the pupils. The course began with the crayfish as being larger and easier for young pupils with no experience for their first laboratory study. After a month or two with crustaceae and insects the work went back to the amoeba and started the laboratory series of animal types. The first part of the year was given to the animal studies and the latter part to plants. There were no semester divisions then. The same process was repeated with the plants, beginning with pleurococcus. Each type was studied in detail, consuming three or four weeks on

such types as the crayfish, frog and fern. As we have said there was no textbook available and the teacher had to supply the needed explanations and the additional information about other forms in each group with the aid of specimens he collected round about Chicago and some marine specimens from Woods Hole. There were no dealers handling laboratory live supplies and the teacher had to go out and collect hydra, crayfish, frogs, etc., for laboratory use. This resulted in the use of much material preserved in alcohol, as formaldehyde and other preservatives, had not come into use. There was much dissection and considerable use of the compound microscope especially in the plant studies.

The pupils were young, first year high school, and no one escaped the study. It was not strange therefore, what with the prolonged work over distasteful alcoholic material, that the subject of biology became unpopular with the students. There were many complaints from parents, some of which got into the daily press. Even editorials on the general worthlessness of the subject appeared and it began to look as though the biology teachers might be out of a job. But the superintendents stuck by Mr. Boyer. The teachers gradually learned how to handle the subject better. Mr. Boyer soon gathered his laboratory instructions together into a book which was published by D. C. Heath and Co., the first "Laboratory Manual of Biology" for high schools.

But another difficulty arose. The high schools after the World's Fair, began to increase rapidly in attendance. It soon came to be difficult to supply sufficient laboratories equipped in the standard fashion and some schools were compelled to use ordinary class rooms for biology. Teachers with laboratories had to hear recitations in the laboratory with pupils seated around the big tables. The trouble became more and more acute as the incoming freshman classes increased in size. At last the authorities decided that matters would improve greatly if biology was made a second year study and the distaste for the subject on the part of some pupils relieved by making biology elective with history. So this was done. Biology teachers, without a job for a year, became physiography teachers temporarily, the subject substituted for the required biology. The dearth of laboratory and class room space was relieved considerably by cutting out the extra laboratory hours and making physiography a five hour subject instead of seven.

Meanwhile biology was becoming more and more pure zoology and botany courses and this was accentuated when semesters took the place of fall, winter and spring terms. Biology was treated as two half year subjects with enrollment of new pupils each half year. Another movement now took place making botany and zoology each a whole year subject and most of the larger schools adopted the whole year plan with separate laboratories and teachers for each subject. A half year of "advanced" work in each subject was made elective for the third year of high school. Later the advanced courses became in some schools an entire second year's study of either subject.

The teachers of biology got along for several years without a textbook. No textbook was available. But the need of a text became more and more urgent as the teaching of the subject broadened and came to include more of the life relations of living things and less of structure and anatomy. Mr. Boyer realizing this, began a textbook of zoology, but the press of school duties allowed little time for the textbook work. So he took a leave of absence for the purpose of writing the book, but being drawn continually into school affairs the book did not get on very fast and when he was appointed assistant superintendent to Superintendent of Schools Andrews the work came to a standstill. After the lapse of this stormy period he became assistant principal for Francis Parker and the book was dropped. Some one in authority now applied to the Appletons for their help and Professor Coulter and President Jordan were delegated the task of preparing a textbook. As they had no model to guide them they hardly knew how to combine in one book the forms and life relations of plants and animals. They finally compromised by each writing two books, "Plant Relations" and "Plant Structure," "Animal Life" and "Animal Forms." These were good books since both authors were past masters of the English language and also of the respective sciences. But a practical difficulty arose when the teachers came to use the books. All the books were needed but the pupils could not be asked to buy so many books, four books in the case of the half year of each subject. Finally to solve this difficulty a committee of three teachers was given the task of combining the two books in each subject into one book. This they did with fair success and the new books were published as "Plant Studies" and "Animal Studies." These were very satisfactory books and were used for several years. In later years many biological textbooks were

produced mostly by college professors, but college men rarely keep pace with the evolution going on in the high schools and the textbooks they turn out are seldom any advance over their predecessors or they are unsuitable for various other reasons. Teachers of biological subjects have been wishing for a long time for the perfect book—instead they have had to take the one least objectionable and adapt it to their needs.

This paper would be incomplete without a resume of the activities of the biology teachers. It was not long after the introduction of biology into the schools before a "Biology Round Table" was organized. The Round Table, for a number of years met monthly or semi-monthly to discuss, for the most part, methods of teaching the subject, for the subject was unorganized and the teachers felt strongly that methods suitable for the college were not suited to the high school. Every three or four years the teachers rewrote the course of study for biology, and later for botany and zoology, after much discussion first in committees and then in the whole Round Table. Later with the division of biology into distinct courses of botany and zoology, through committees of teachers, new laboratory manuals were written and published.

This process of writing and rewriting new courses of study for the biological subjects has been kept up to this day. The latest one, not yet in universal use, was made under the authority and command of Superintendent McAndrews. It attempts to make use of the unit system of organizing the subject and to relate all the work to the principles enunciated by the Committee on Secondary School Science of the N. E. A.

Of late there has risen a feeling among teachers of botany and zoology that these subjects do not quite answer the need for biology in the high school and that the organization of a one year course in real biology, putting emphasis on the life problems of living things, would be very desirable and also, perhaps, a return to making it a required subject, at least, for some of the courses in the curriculum. This type of biology has been taught for several years in at least one of the high schools of the city, notably in the Lane Technical high school and a laboratory manual of biology has been written by Miss Smallwood, head teacher of biology in that school and is now in print.

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"Knowledge which is acquired under compulsion has no hold on the mind."—*Plato.*

# THE TRAINING OF SCIENCE TEACHERS, HERE AND ABROAD[1].

BY N. HENRY BLACK,
*Harvard University, Cambridge, Mass.*

## A FEW STATISTICS FROM NEW YORK CITY

In a recent report[2] called "The Teaching of Science as a Way of Life," John L. Tildsley, a district superintendent of high schools for the city of New York, gives us the following data about teachers of science:

*Formal Training.*

| | | |
|---|---|---|
| 1. B. A. or B. S. | 500 | |
| 2. No college degree | 6 | |
| Total, Teachers and Laboratory Assistants | 506 | |
| 3. M. A. or M. S. | 203 | 40.1% |
| 4. Ph. D., D. Sc. or M. D. | 29 | 5.7% |
| Additional hours of graduate study not included in 3 or 4 | 108,531 hours | |
| Average per member of entire staff | 214.5 hours | |

*Professional Attitude.*

| | | |
|---|---|---|
| Members of Scientific Societies | 332 | 65.6% |
| Not members of Scientific Societies | 174 | 34.4% |
| AV. society per member of entire staff | 1+ | |
| Read regularly some scientific journal | 401 | 80.2% |
| Do not read regularly some scientific journal | 99 | 19.8% |
| AV. scientific journals read | 2.15 | |

Dr. Tildsley remarks: "These figures reflect a praiseworthy condition of the great majority of teachers. It is to be regretted that 174 teachers do not sense the stimulus that comes from association with the active, growing members of the craft. The 99 teachers who do not regularly read some scientific journal are hardly likely to be welling springs of inspiration to their pupils. Nevertheless, I doubt that the teachers of any other subject would excel this science group in training and in professional attitude."

## FACTS FROM OHIO

It would be interesting and valuable if someone would compile similar statistics in regard to our other great cities and if we could in addition get similar information concerning the large numbers of science teachers in the smaller high schools. Mr. E. W. Phalen in a recent number[3] of the Journal of Chemical Education has

[1]Summary of a talk given at the General Meeting of the Central Association of Science and Mathematics Teachers held on Nov. 30, 1929, at the University of Chicago.
[2]Bulletin of High Points in the Work of the High Schools of New York City, Vol. X, October, 1928, page 6.
[3]Journal of Chemical Education, December, 1929, Vol. VI, pp. 2196-2202.

given us some illuminating data on the status of the chemistry teacher in the Ohio high schools. For example, he found that among the county high schools about 5% of the chemistry teachers also taught 5 other subjects, about 16% had 4 other subjects, 31% had 3 other subjects, and about 28% carried 2 other subjects. In short, about 81% of the science teachers were teaching 2 or more other subjects besides chemistry. In the city high schools he found that about 29% taught only chemistry, about 26% taught one additional subject, and about 19% taught two other subjects.

In regard to the teaching load of the chemistry teacher, Phelan says: "Although many teachers in city high schools had but two subjects to teach, usually chemistry and physics, or chemistry and general science, their complaints of too many subjects to teach were just as numerous as those from county teachers, many of whom had five and six subjects to handle.

*Table II—Teaching Load.*

| Number of subjects taught in addition to chemistry | County | City | Total |
|---|---|---|---|
| 7 | 1 | 0 | 1 |
| 6 | 1 | 0 | 1 |
| 5 | 8 | 2 | 10 |
| 4 | 26 | 1 | 27 |
| 3 | 50 | 14 | 64 |
| 2 | 46 | 31 | 77 |
| 1 | 25 | 42 | 67 |
| 0 | 5 | 36 | 41 |
| | 162 | 126 | 288 |

These "other subjects" included practically everything in the curriculum. Examples chosen at random are:

Chemistry, manual arts, biology, business arithmetic.

Chemistry, general science, biology, physics.

Chemistry, Latin, social sciences.

Chemistry, general science, agriculture, algebra.

Chemistry, algebra, geometry, general science, English.

As to the training of the chemistry teacher he states: "The following tables show that the city high schools have in general teachers with a good training in chemistry and in special courses in educational methods, and with several years of experience. On the other hand, the county high schools, having too few students to require more than a fraction of the time of a chemistry teacher, are forced to hire inexperienced teachers, many of whom have had no more than the introductory course in college chemistry. As physical chemistry is usually given during the third or

fourth year of the college course of a student majoring in chemistry, the list of teachers who have studied physical chemistry probably includes all of those who have had chemistry as their primary interest in college."

*Table IV—Training in Chemistry.*

| Courses studied: | County | City | Total |
|---|---|---|---|
| General chemistry | 161 | 124 | 285 |
| Qualitative analysis | 128 | 111 | 239 |
| Organic chemistry | 100 | 87 | 187 |
| Quantitative analysis | 86 | 97 | 183 |
| Physical chemistry | 36 | 62 | 98 |
| Agricultural chemistry | 31 | 22 | 53 |
| **Major Subject:** | | | |
| Chemistry | 64 | 82 | 146 |
| Education | 1 | 2 | 3 |
| **Education Courses Studied:** | | | |
| Principles of high-school teaching | 153 | 121 | 274 |
| Classroom administration | 127 | 100 | 227 |
| Methods of teaching science | 94 | 88 | 182 |
| Methods of teaching chemistry | 33 | 70 | 103 |

*Experience of Teachers.*

| No. of Years Teaching Chemistry | County | City | Total |
|---|---|---|---|
| 1 | 63 | 9 | 72 |
| 2 | 30 | 13 | 43 |
| 3 | 23 | 14 | 37 |
| 4, 5 | 18 | 26 | 44 |
| 6-10 | 25 | 34 | 59 |
| 11-20 | 3 | 25 | 28 |
| 21 + | 0 | 5 | 5 |

Since we have not yet much such data at hand, I shall spare you further statistics and confine myself to a summary of my personal observations, with comments.

## Impressions from Experience

From my experience with the science teachers who come for courses in the Graduate School of Education at Harvard, I gather that their training has in general been inadequate and casual. This applies to both the academic training in subject matter and to the professional training in methods of teaching. If one seeks for the reason for this state of affairs, if it does exist, he finds that the most fundamental reason seems to be this, that the demand for science teachers is greater than the supply of well-trained teachers in this country. Another factor enters into the situation which I think is unique in this country, namely, that a teacher is very often called upon to teach science, particularly general science, without ever having expected to do so or

without claiming to be prepared to teach the subject. The exigencies of our rapidly growing high schools and the sudden increase in science classes have perhaps made this a temporary necessity. But when all is said and done I suspect that we Americans by and large do not yet really believe that any special training is necessary for a science teacher. We still naively believe that a mature man or woman ought to be able to do a tolerable job by keeping at least a week ahead of the class. Of course, we who are here realize that this is quite inadequate and that the results of such a procedure are disastrous.

### Lack of Opportunities

But I think there is another reason which accounts for the lack of professional and academic training in this country and that is that our higher institutions, colleges and universities especially, have until recently offered very little in the way of opportunity for training. Our science courses have generally been arranged for the man or woman who is going to be a specialist in some one field of science, such as botany, physics, or chemistry. The so-called general courses, which introduce one to the subject and which are so necessary for the prospective teacher of elementary science, let us say, are very often inadequately given. And as for opportunities for learning the technique of teaching science and for acquiring some facility in handling demonstration apparatus and learning where and what to get in the way of supplies and equipment—one can almost name on the fingers of one hand the institutions which regularly furnish such courses.

### What Academic Training is Needed

Now what sort of training should we like the science teacher of the future to have? For example, how much academic work and what sort of academic work ought a *general-science teacher* to have had? Surely we can say at once that he must have had an introductory general course in physics, chemistry, biology, geology, and astronomy, and should have had at least a second year of work in some one of these sciences, preferably in physics and biology. Then too he must have taken some course which will lead him to the literature of these great fields, for the habit of wide reading is perhaps more necessary for the general-science teacher than for one in any of the special sciences. In my brief experience with training science teachers, I have found very few men and women who have had adequate academic training in more than one field of science. In *biology* we would, of course,

say that the prospective teacher must have taken four years of work in that field. The collegiate courses in biology would naturally include an introductory course in botany and zoology, an introduction to cryptogamic botany, courses on the morphology and anatomy of higher plants, comparative anatomy of vertebrates, physiology or the dynamics of vital processes and if possible the natural history of insects. But this is not enough. He ought also to have had work in physics, chemistry, and geology, because these subjects are so closely related to biology. As we all know from experience and statistics, there are very few high schools except the large high schools where the biology teacher is called upon to teach only biology. For the *physics teacher*, we should without hesitation require at least two years of mathematics in addition to four years of college work in physics, including a good general course, laboratory courses in electrical measurements and in physical optics, at least an introduction into thermodynamics, and into the theories of modern physics. In this college work in physics I would urge the value of a course on the history of physics and on physical manipulation, such as glass-blowing and machine-shop work. The teacher of physics must, of course, take an elementary course in biology and in chemistry. And it would be highly desirable if he could squeeze in a bit of astronomy. For the *chemistry teacher* we would urge that the four years' work in chemistry should include a full year of general inorganic chemistry, a semester each of qualitative analysis, quantitative analysis, and organic chemistry, an introductory course in physical chemistry, and a course on the history of chemistry and modern theories of chemistry. But the chemist of today must also be very familiar with modern physics because the dividing line between physics and chemistry is fast being obliterated. The above brief outline will suggest the scope of the academic work which the science teachers of tomorrow are urged to take in our colleges today.

## What Sort of Professional Training

Now as to their professional training. Perhaps you will expect me to lay out a large amount of this sort of work since I come from an institution which has just begun to require two years' preparation for the master's degree. But I must face facts as they are and shall be very modest in my recommendations, which are based largely on my own experience and the experience of the teachers whom I have known in the school room. This is to be

considered the irreducible minimum. Surely you will grant that a general course on principles of teaching is necessary and that a course on educational psychology is to be recommended. Certainly every high-school teacher should get some insight into the history, aims, and organization of our modern secondary schools. In these days, too, a short course on educational measurements ought to be taken, not because I believe that all of our educational-measurement work is of very great value but simply because the teacher ought to have some standards by which to evaluate the enormous mass of so-called measurements in the field of education. In order to help the teacher now in service who wishes to improve his professional training I will venture here to suggest a few recent books:

Walter S. Munroe—Directing Learning in the High School, Doubleday, Doran and Company, 1927.
Arthur I. Gates—Psychology for Students of Education, The Macmillan Company, 1925.
Aubrey A. Douglass—Secondary Education, Houghton, Mifflin Co., 1927.
Percival M. Symonds—Measurements in Secondary Education, The Macmillan Company, 1927.
Edgar W. Knight—Education in the United States, Ginn and Co., 1929.

Finally I would suggest, and this I do with some modesty because it is my own field, a short course on the special methods of teaching science in our secondary schools. Right here let me recommend a new book which has just been published by Blackie and Son, Ltd., in London, called "Science Teaching—What it was—What it is—What it might be" by F. W. Westaway, formerly one of H. M. Inspectors of Secondary Schools.

## Two Years for the Master's Degree

The two-year course at Harvard lays great emphasis on "practice teaching." This we feel to be absolutely essential. We require the prospective teacher to take charge for a half-year of one high-school class which meets every day. This work is done in suburban high schools which are convenient to the University and is under the supervision of an older teacher of the school and of the professors in the School of Education. This is the only way in which a teacher can get a feeling of being at home in the classroom, which means so much in starting a career as a teacher. The second point which we are trying to emphasize in our two-year course for the master's degree is the necessity of doing more academic work. We plan the student's curriculum so that he may devote from a quarter to one-half his time to such work.

It is distinctly stated in our catalog: "No candidate preparing to teach in a secondary school will be recommended for the Ed. M. unless his command of the subject he proposes to teach is satisfactory to the Faculty."

### Training of Teachers Abroad

Now just a word about the conditions which one finds abroad, especially in England, France, and Germany, as regards the training of science teachers.[4] What can we learn from these foreign countries which will be helpful to us in our problem here? In the first place, I think every observer of schools abroad comes back with a profound respect for the academic training of their teachers in secondary schools. It has been more extended and more intensive than we usually find here. For example, in the German Gymnasium and other schools of that grade we find that a large number of the teachers, about half, have their doctor's degree (although they are not required by law to have them) and this, of course, means intensive and prolonged study in one field of science. Another fact which I think will not be denied is that our colleagues across the Atlantic have very great faith in learning to teach by teaching; that is, much more elaborate facilities for acquiring the technique of teaching are provided in Germany, France, and England than we find in this country. It is the usual thing in Germany for a man who has spent three or possibly four years at the University and has passed his state examinations to be attached as teacher to a school which is selected for him by the state because of its excellent work in science. Here the candidate is guided in his reading by the Director of the school and is little by little introduced to the work of teaching, very gradually at first but toward the end of the year assuming more and more responsibilities. This so-called *Seminarjahr* is, according to Dr. J. F. Brown, the keystone in the arch which binds together and holds in place high academic scholarship on the one side and thorough pedagogical training on the other. In some universities courses are offered which supplement this practical work in the schools and which deal with the history of education and with educational psychology. However, one does not find that lectures on the theories of education play a very large role in the German university.

After the first year of apprenticeship the German candidate

[4]For more details see such books as: Lance G. E. Jones' *Training of Teachers in England and Wales*—Oxford Univ. Press, 1924. F. E. Farrington's *French Secondary Schools*—Longmans, Green & Co., 1915. James E. Russell's *German Higher Schools*—Longmans, Green & Co., 1913.

spends another year (the *Probejahr*) for little or no pay. During this year he carries nearly a full-time schedule of 24 hours of teaching per week under the direction of older teachers. Then he serves a longer or shorter time, as circumstances may determine, as a substitute teacher until he can be given a regular position. This rather long preparation and expensive training in practical school work is possible because so many men and women are eager to take these positions that the requirements can be made very stiff. This redounds to the benefit of the schools.

### Provision for Growth

Finally, I wish to add that the Europeans seem to recognize that science is a growing field of study and that science teachers must therefore be given opportunity to extend their knowledge and to improve their professional technique of teaching. So one finds summer courses planned especially for teachers which enable them to catch up in the newest discoveries in science. Some of these are unusually successful, such as the summer school of two weeks given nearly every summer in Göttingen where the very best men on the staff of the different departments of the University cooperate in giving the teachers the very latest results of their own researches. At the physical laboratory of the University of Leyden they have for years carried on practical courses during the summer in instrument making. Many teachers of science avail themselves of this opportunity to learn something of glass-blowing and metal-working.

Moreover, there are in various cities like Berlin, Vienna, Hamburg, and Munich special opportunities provided for teaching the young candidates who are in training for the regular science-teaching positions to acquire the technique of demonstration and of laboratory teaching. Professor J. B. Conant of Harvard tells me that in the University of Vienna they have a special room equipped with several lecture tables where the candidates actually perform a series of the more important yet difficult demonstrations which are required in their school teaching. Surely this is a field where we in America have been sadly negligent, and we can hardly blame young teachers for being so timid and bunglesome in their classroom demonstrations. While we must admit that England and France and Germany have not yet accepted our enthusiasm for educational measurements, we shall have to acknowledge that the classroom teacher, as we see him at work abroad, is much better prepared than we usually find him to be in the American high school.

## UTILIZING THE NATURAL INTERESTS OF PUPILS IN TEACHING BIOLOGY, PART II.

By O. D. Frank,

*School of Education, The University of Chicago.*

### "Indian Runners."

Take your class to the field or to a museum. Find a comfortable seat. Tell the pupils they are now "Indian Runners." Send each one away to find the answer to a given question. When he has found the answer he returns to the teacher and gives his report. If his report is correct, he is given one point. If he fails, he must make additional attempts until he succeeds in bringing the correct answer. The pupil who secures the greatest number of points wins the game.

The game may be varied by dividing the class into two teams and the team having the greatest number of points at the end of the hour wins the game.

The following will serve to illustrate the type of questions asked:

1. Are the leaves of the elm tree opposite or alternate?
2. Which shoulder of an elm leaf is the higher?
3. Are the low shoulders of elm leaves away from the branch or toward the branch?
4. Describe the notches on the edge of an elm leaf?
5. Describe the ribs on an elm leaf.
6. Do all elm leaves have the same number of ribs?
7. Are elm leaves smooth or rough?
8. What is the shape of an elm tree?
9. Where are the buds on an elm tree?
10. Describe the fissures in the bark of an elm tree.
11. Can a grasshopper be drowned by holding his head under water? Explain.
12. How many eyes has a grasshopper?
13. Where are the ears of a grasshopper located?
14. Are the antennae of a grasshopper below or above his eyes?
15. Find three ways in which a grasshopper is fitted to live in the grass.
16. How far can a grasshopper hop?
17. Do all of a grasshopper's legs have spines on them?
18. Discover why a grasshopper spits "tobacco juice."
19. On what part of a grasshopper's body are his wings fastened?
20. On what part of a grasshopper's body are his legs fastened?

### Seed Study.

At the beginning of school suggest to your class that making a seed collection affords an interesting way to become acquainted with plants. The easiest and most scientific way of identifying plants is through a study of their seeds. The roots, stems, bark, leaves, buds and other parts of plants may be very similar to those of another plant belonging to another family but the seeds are usually distinctive.

If each member of the class will save the seeds of the fruits and vegetables eaten, and will secure any other seeds that he can, and will bring them to class where they may be placed in properly labeled containers, a most interesting and varied collection can soon be made.

The following list will suggest some of the kinds of seeds that may be secured:

| *Fruit seeds* | *Grains* | *Melon* | *Legumes* |
|---|---|---|---|
| apple | wheat | water melon | beans |
| pear | corn | citron | peas |
| cherry | rye | cantaloupe | locust |
| plum | oats | cucumber | clover |
| prune | barley | squash | peanut |
| grape | | pumpkin | |
| orange | | gourd | |
| lemon | | | |
| rose | | | |
| almond | | | |
| peach | | | |

| *Vegetables* | *Nuts* | *Flowers* | *Shade Trees* |
|---|---|---|---|
| cabbage | pecan | four-o'clock | maple |
| radish | hickory nut | morning glory | box-elder |
| turnip | chestnut | sunflower | ash |
| beet | hazel nut | | elm |
| red pepper | walnut | | catalpa |

Each pupil should provide himself with a board about one foot square. The end of an apple box or an orange crate is ideal. The board should be made smooth on one side and just before the seed study is to be made a thin layer of plasticine should be spread over the smooth surface of the board.

When all of the boards are ready each member of the class is given a bag containing five of each kind of seed with the instructions to arrange the seeds on the board in the most scientific and interesting manner possible.

Walk among your pupils and note how each attacks the problem. This device affords a most interesting psychological study.

## Terrapin Derby.

As early in the spring as possible secure a terrapin for the biology or general science room. If you have a Science Club, let the terrapin be the club mascot. Suggest that other terrapins be brought in. When three or four have been secured, it is time to discuss the possibility of putting on a Science Club Terrapin Derby some time in May.

Where can terrapins be secured? What do they eat? How many kinds of terrapins are found in this locality? Can we have them sent to us? How can you tell one kind from another? Will they run? How could you have a terrapin race? These are a

few of the many questions that will be asked concerning terrapins.

When interest has been thoroughly aroused, it is time to make plans for the derby.

*Plans for the race:*

Secure a terrapin.

Feed him and have him in good condition for the race.

Each terrapin must have a name.

A general manager should be elected by the Club. He will select a staff to assist him. The general manager will appoint all necessary committees and will have general charge of the derby.

The following are some of the committees that will be needed. Others may suggest themselves to the business manager.

Committee No. 1. Booking committee. This committee will have charge of all entries. Each entrant will be given a number. The number must be fastened securely on the back of the terrapin the day before the race. The terrapins must be placed in the hands of the booking committee the day before the race.

Committee No. 2. The tickets committee. This committee will have charge of the sale of tickets. A general admission of ten cents will be charged. This committee will take up tickets at the gate.

Committee No. 3. The ring committee. This committee will find a suitable spot for holding the race. Rope and stakes will be needed for the outer ring which should be 75 feet in diameter. A fifty foot ring made with whitewash or a string fastened securely to the ground should be made within the outer ring.

Committee No. 4. The judge committee. This committee will secure two competent judges who will judge all races.

Committee No. 5. Prize committee. This committee will secure suitable prizes and will place them in the hands of the owners of the winning terrapins.

Committee No. 6. Police committee. This committee will have charge of the ring and it shall be its duty to see to it that none but the proper officials come within the ropes.

Committee No. 7. Starting committee. The members of this committee will take the terrapins that have been entered for a given race to the center of the ring and at a given signal will release them. The terrapin that crosses the line first is the winner of the race.

A number of heats may be arranged for, and the winner of each of these heats may be entered in the final race.

### Earthworm Castings.

Locate a plot of ground fairly well covered with earthworm castings. Carefully gather the castings from a square foot of ground. Dry the castings thoroughly and weigh them accurately. Estimate the number of tons of soil per acre brought to the surface by these "living plows."

### Leaf Life-histories.

1. Select five common trees growing in your neighborhood, take a bud from each of these trees before the buds begin to open in the spring. Mount these buds on a large cardboard placing them in a perpendicular row about six inches apart at the left of the cardboard.
2. When the buds open obtain a tiny leaf from each tree and press carefully. Mount each leaf to the right of the appropriate bud on your cardboard. Continue this procedure once each week until the leaves are fully developed. Record the date on which each leaf was obtained under the leaf as you mount it on the cardboard.

When your collection is complete, summarize the facts you have learned concerning the growth of leaves in tabular form. You will find this to be a most fascinating and interesting study.

### Animal Growth.

Weigh a pup each week for a number of months. Prepare a graph to show facts learned.

### Leaf Collections.

Collect leaves to show variation in size, shape, color, thickness, shades of green, length of petioles and indentations of leaf margins.

### Raising Silk Worms.

When the buds of the mulberry trees begin to open in the spring, send fifty cents to Mr. F. A. Keleher, P. O. Box 141, Pennsylvania Ave. Station, Washington, D. C., for silk worm eggs.

Place the eggs in a box and keep a supply of mulberry leaves near them. The eggs will hatch in a day or two. The larvae need no care except to be supplied with fresh mulberry leaves. The leaves should not have moisture on them nor should any water be given to the worms.

The box containing the worms need not be covered as they will not leave the leaves.

The worms should be supplied with small branches when they are ready to spin their cocoons. When the moths emerge from the cocoons, they may be kept in an open pasteboard box. If the eggs are kept in a cool place, they may be kept until the following spring when they will hatch out upon being brought to a warm place.

It is a most fascinating study to watch the silk worm go through its metamorphosis from egg to adult.

### Blue Monday Sermons.

"A good start is half the race." The week may be started in "tune" by giving a little five-minute talk on Monday morning. The talk may be given by the teacher or students may be given the privilege of giving the "Blue Monday Sermon." The only requirement is that the topic must begin with "B." The following have proven to *be* interesting topics:

| | | |
|---|---|---|
| Bees | Beans | Beauty |
| Bears | Buds | Bravery |
| Bunnies | Blossoms | Beeing bothered |
| Bats | Branches | Bragging |
| Boa constrictors | Blue Bells | Blustering |
| Birds | Berries | Brothers |
| Beetles | Bushes | Broadcasting (gossiping) |
| Bugs | Bananas | "Buttinskies" |
| Babies | Banyan tree | Blessings |
| Butterflies | Bacteria | Being natural |

### JUNIOR AUDUBON CLUBS.

The formation of a Junior Audubon Club is a very valuable elementary science activity. Last year more than 355,000 boys and girls were members of these clubs. In the state of Illinois alone there were 322 clubs with 13,209 members. Membership in an active club in charge of a good teacher gives the child a knowledge of several birds each year and establishes an interest that will provide pleasant and profitable entertainment for leisure hours throughout life. Information may be obtained by writing T. Gilbert Pearson, National Association of Audubon Societies, 1974 Broadway, New York City.

### CRIME MORE PREVALENT IN THE CITY THAN IN THE COUNTRY.

According to a recent report of the Bureau of Census, crime is far more prevalent in the city than in the country. Of the total number of prisoners for whom the location of the crime was reported, 77.8 per cent were imprisoned for crimes committeed in urban places, and rural sections were the scene of only 22.2 per cent of the crimes. In contrast with this all the urban places combined, in 1920, had only 51.4 per cent of the population, and rural territory had 48.6 per cent. Per 100,000 of population the urban places show a commitment ratio of 25.1 as against the rural ratio of 7.6.

## SNAKES—HARMLESS AND POISONOUS.[1]

By A. I. Ortenburger,[2]

*University of Oklahoma, Norman, Okla.*

The suggestion that many snakes are harmless will, perhaps, be received with some doubt, by many readers, yet it is a fact well-known to herpetologists—those specialists who make a study of reptiles and amphibians—that relatively few of the snakes in the United States are poisonous. In spite of the many stories appearing in the newspapers every summer, there are relatively few actual deaths each year in North America as a result of bites of poisonous snakes.[3] Most of the deaths in the world from this cause occur in India, Brazil, and Australia.[4] In Europe, the number is relatively somewhat large, probably owing to the fact that much of the work of reaping and binding the grain is done by hand.

Of the approximately 2,300 known species of snakes occurring in the world, only about 250 species have a poison apparatus well enough developed to render them dangerous. This does not include the sea snakes, or sea serpents as they are rightly called; the sea snakes will be discussed in a later paper. It may be disquieting to learn that we have with us in this world even so small a number of poisonous species as 250, but as a matter of fact, many of these—perhaps a third—can be disregarded, either because of their very small size or because of their extreme rarity. This leads then to the interesting fact that of all the known species of snakes, less than 7.5% need be considered as dangerously venomous to human beings.

Of the 193 species of snakes found in North America, only 25 are poisonous.

These are the two species of Coral Snake, the Copperhead, the Cotton-mouth Moccasin, the two forms of the Massasauga, the Pigmy Rattler, and 18 species of true Rattlesnakes. However, 9 poisonous species of the large Rattlesnake (genus *Crotalus*) can be disregarded; three of them occur only on certain isolated

[1]This is the first of a series of short articles on reptiles by Doctor Ortenburger, who is a recognized authority in this field.—Ed.

[2]Contribution from the Zoological Laboratory of the University of Oklahoma, Second Series, No. 100.

[3]In 1928 there were recorded 607 case reports of snake-bite poisoning in the continental United States. Of these, specific Antivenin serum treatment was used in a total of 433 cases. In this group there were 13 deaths, giving a death rate of 3 per cent. (Hutchison, R. H., Bull. Antivenin Inst. Amer., Vol. III, No. 2, pp. 43-57.)

[4]In a very recent paper (Fairley, N. H., 1929, Bull. Antivenin Inst. Amer., Vol. III, No. 3, pp. 65-77), it is shown that the percentage of deaths from the more common venomous Australian snakes is fairly high, averaging 12% for the Death Adder, Tiger Snake, Brown Snake, and Black Snake. Moreover for the Death Adder alone the fatality rate is 50%!

islands off the coast of Lower California and Mexico, three occur only near the southern end of the peninsula of Lower California, and the remaining three have extremely local distribution areas. This leaves but 16 poisonous species that are at all common in North America. Of these, the two Massasaugas, the Pigmy Rattler, and three species of the true Rattlesnakes are of such relatively small size that they need not be considered. This leaves, then, but 10 poisonous snakes that are really important. In other words, only 5% of the North American snakes are to be feared as poisonous. In other countries it is quite another matter; for example in Australia, there are a total of 115 species of snakes, but 70 of them are venomous, or 60%—quite a difference!

Technically, our poisonous snakes are of two kinds—the *Pit Vipers,* represented by the Copperheads, the Cotton-mouth Moccasins, and Rattlesnakes, and the *Coral Snakes,* which are really miniature Cobras. The Pit Vipers always can be distinguished by the presence of a distinct pit between the eye and nostril, as is shown in the accompanying figures (Figs. 1, 2).

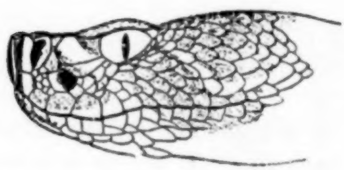

Fig. 1. (From Stejneger.) Florida Diamond-back Rattlesnake, showing pit.

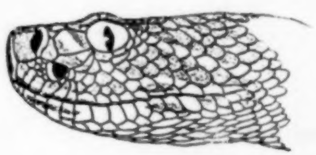

Fig. 2. (From Stejneger.) Prairie Rattlesnake, showing pit.

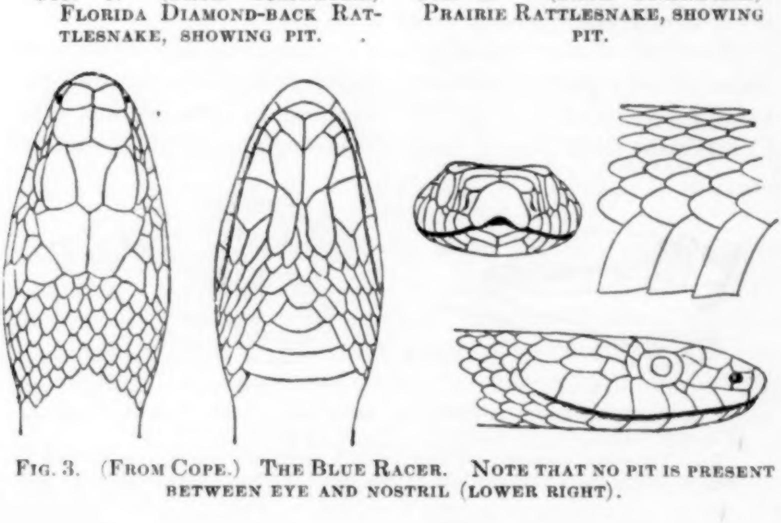

Fig. 3. (From Cope.) The Blue Racer. Note that no pit is present between eye and nostril (lower right).

Our harmless snakes *always* lack this pit! (Fig. 3.) The group which includes the Cobras, on the other hand, generally has no external features that make their identification possible. Fortunately for those of us who live in the United States, the Coral Snakes can very easily be recognized by the bright coloration of black, yellow, and red rings extending around the body. However, not all snakes with black, yellow, and red rings are Coral Snakes. Certain harmless snakes, such as the Scarlet Snake (*Cemophora*) and at least one of the King Snakes (Fig. 4)

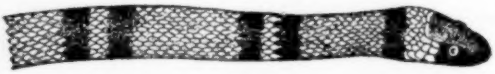

FIG. 4.
COLOR PATTERN OF LAMPROPELTIS, KING SNAKE. (FROM STEJNEGER, AFTER JAN.) NOTE THAT THE YELLOW IS BORDERED BY BLACK.

FIG. 5.
COLOR PATTERN OF ELAPS, CORAL SNAKE. (FROM STEJNEGER, AFTER JAN.) NOTE THAT THE BLACK IS BORDERED BY YELLOW.

exhibit the same colors. But in the arrangement of the colors, the Coral Snakes are unique; the black rings are *always* bordered on either side by yellow rings (Fig. 5), and the colors never occur in any other arrangement.

There are, of course, much more fundamental differences than those of color pattern between these harmless snakes and the Coral Snake. One such difference is shown in the dentition. The Coral Snake skull (Fig. 6) shows the strong fang located anterior-

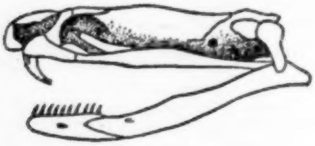

FIG. 6.

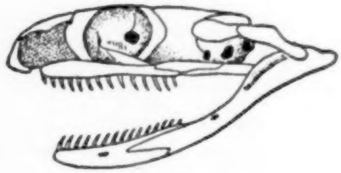

FIG. 7.

FIG. 6 SHOWS PROFILE VIEW OF SKULL OF ELAPS, CORAL SNAKE. (FROM STEJNEGER, AFTER JAN.) NOTE FANG IN UPPER JAW.

FIG. 7 SHOWS PROFILE OF SKULL OF LAMPROPELTIS, KING SNAKE. (FROM STEJNEGER, AFTER JAN.) NOTE SMALL EQUAL TEETH.

ly on the upper jaw while in the harmless King Snake (Fig. 7) no fang is present, the teeth all being short and solid, hence not capable of injecting venom; moreover, of course, there is no poison apparatus present in a harmless snake.

Perhaps enough has been said to substantiate the statement that many of the common ideas regarding the appearances of poisonous snakes do not hold. It is a popular misconception that a snake is necessarily poisonous if it has a triangular-shaped head, or a short and thick body.

There are probably more untrue stories told about snakes than about any other single subject in the whole field of knowledge. An article will deal with this alone in a later issue. Of the stories of popular origin which one hears, only an extremely small number are to be believed. One may hear many weird stories about the Hoop Snake, yet such a snake does not exist. The Blue Racer is said to be the fastest serpent, but this is untrue. The Spreading Viper, or Puff-adder, better called the Hog-nose Snake (Fig. 8), although he hisses and blows when disturbed,

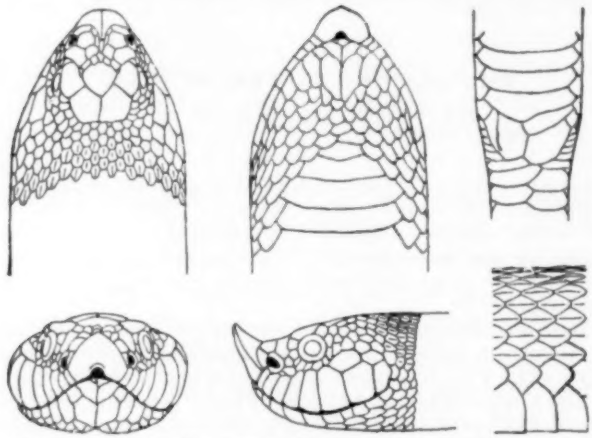

FIG. 8. (FROM COPE.) HOG-NOSE SNAKE. A HARMLESS FORM NAMED BECAUSE OF THE SHAPE OF THE "NOSE."

does not have a poisonous breath; he is not even afflicted with halitosis. A Rattlesnake does not possess a rattle for every year of his life, nor is he rendered harmless by removing the particular pair of fangs that happen to be functioning at any one time. He does not often rattle when disturbed or approached, as is popularly supposed, and he usually does not strike. Incidentally, a Rattlesnake cannot strike any great distance—specifically, not over two-thirds of his length.

Nor should all snakes be exterminated. Rather it should be emphasized that a large proportion of both our harmless and poisonous snakes are distinctly beneficial. The Blue Racer, supposedly possessed of unbelievable speed and agility, and indeed thought by many to be poisonous, has a distinct economic value to the farmer, and thus to all of us. A large proportion of his food consists of grasshoppers, field mice, and other animals that are injurious to men. And so with the Bull Snake, the so-called Chicken Snake, the Whip Snake and many other entirely harmless varieties; their food habits make them deserving of the protection of man. Even the much-hated Rattlesnake has something in his favor, for he lives largely on the very destructive small rodents.

The only treatment for a poisonous snake bite that is of much avail is the injection of the serum which is specific for that kind of snake. There is a wide difference in the venoms of the two major groups of poisonous snakes—the Pit Vipers and the Cobras. Regarding the types of venoms and the specific methods of treatment more will be said in a later article.

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## THE LEANING TOWER OF PISA.

By W. F. Schaphorst, M. E.,

*Newark, N. J.*

Not long ago I saw a very interesting photograph of engineering equipment installed in the vicinity of the Leaning Tower of Pisa. Engineers are now "fixing" the foundation. I endeavored to obtain a copy of the photograph for use in connection with this article, but the contractor could not give one to me because, he said, it was the property of a European concern.

Air compressors and much cement were in evidence in the photograph. These compressors are used for pumping air and liquid cement through tunnels beneath Pisa to solidify the foundation under and around the leaning tower, making falling an impossibility. The engineers are digging pits around the tower and are drilling openings toward the foundation and directly beneath it and are pumping those openings full of high grade cement.

In other words a comparatively small amount of earth is removed from beneath the tower and as rapidly as it is removed it is replaced with cement. Eventually, therefore, there will be no earth directly beneath Pisa. It will be standing on solid cement and when completed there will be no possibility whatever that Pisa will ever fall over due to loss of equilibrium. During recent years the world has become alarmed over the rapidly increasing rate of inclination of the tower. The greater the lean the greater the pressure on the "toe" or lowest edge of the tower's foundation. As soon as the toe rests on a sufficient area of solid cement or concrete, there will be no more settling. Pisa will continue to lean for many centuries to come.

## BACKGROUND AND FOREGROUND OF GENERAL SCIENCE.

## No. VIII. MICROSCOPIC LIFE.

By Wm. T. Skilling,

*State Teachers' College, San Diego, Calif.*

Objection has been made to the use of such a subject as bacteria in a course for young pupils on the ground that what is not seen is not appreciated. Bacteriology, moreover, is a laboratory subject for the research department of the university or medical college. Granted, but there are few sciences however intricate and advanced but have their simpler phases which make an appeal to the general science student.

The important thing is to find the proper mode of approach to a difficult subject. A path can usually be found along which children may be led with pleasure and profit.

One natural and interesting introduction to a study of things too small to be seen with the unaided eye is to give at least one demonstration with a microscope. A little hay soaked for a few days in water will furnish the swift moving paramecia, and decaying pond leaves may supply some of the sluggish amebas. One look at these wonders will infect the child's mind with an interest which will last for years and the remembrance of it will make him receptive to information about the unseen world of little things.

The *work* of lower forms of life including bacteria, yeasts and molds is a phase of the subject easily comprehended and of greatest importance. Bread mold is good demonstration material. An experiment with yeast illustrates the general topic of fermentation. A few crumbs of yeast cake placed under a test tube filled with sweetened water and inverted in a shallow dish of water produce carbon dioxide gas in the tube. In clear water it will not work, for the gas is made by breaking down the sugar. No gas forms if the sugar solution is too strong, for yeast will not work in a strong solution. Advantage is taken of this fact in preserving fruit with sugar.

In discussing the work of bacteria it ought to be pointed out that causing disease is rather the exception than the rule. The work of most of them is very beneficial. Decay is as useful a process in the world as growth, for without it there would soon be no life or growth. And bacteria and other low forms of organisms such as mold are the agencies that bring about decay.

Explain the products of decay. Mainly carbon dioxide gas

going back into the air whence it originally came and a little mineral matter to enrich the soil. Or, if partial decay underground takes place humus, so important for soil fertility, is the result.

Another group of very useful microscopic organisms are the nitrogen gathering bacteria living on the roots of legumes, such as beans, peas, clover, etc. They change nitrogen of the air into compounds that plants can use.

Pupils should find for themselves the little swellings called nodules on the roots of various legumes.

Undoubtedly the most interesting approach to our subject is the one that Dr. Paul DeKruif has followed in his "MICROBE HUNTERS." Instruction given in story form finds receptive listeners. A short biographical sketch of the men of science who have traced the connection between disease and bacteria serves a double purpose; it gives the desired information and furnishes a stimulus and incentive to do great deeds.

The following brief sketches, amplified and discussed cannot fail to go home, carrying their message of information and inspiration with them.

Nearly a hundred years before it was known that germs had anything to do with disease a very effective way of combating the germs of at least one disease was discovered. Smallpox was rampant in Europe. It is said that only one in twenty escaped having it.

It was noticed that some milkers had their hands infected by sores on the udders of cows which had a disease resembling smallpox but much milder. Those who had had such sores were immune from smallpox.

A farmer who had thus become immune vaccinated his wife and children by rubbing some of the scab from the cow's udder into scratches made on their bodies. This was the first recorded case of vaccination. It was in 1774, easily remembered as being the year before the Revolutionary War began.

A few years later Peter Plett, a tutor in Holstein vaccinated three boys on the backs of their hands with a pocket knife. When an epidemic of smallpox broke out in their neighborhood these were the only children who did not take it.

Dr. Jenner, who had heard of these and other such cases took a deep interest in the discovery which he believed would free the world of so terrible a disease. He spent much of his life studying the subject and advocating this method of protec-

tion. Jenner is regarded as the discoverer of vaccination.

It was not definitely known that any diseases are caused by germs until 1865. The pupils doubtless know many elderly people who were children then. In that year Louis Pasteur, of France, was employed by the silk manufacturers of his country to study a disease among silkworms which was ruining their industry. Pasteur with the aid of the microscope found the affected worms filled with organisms too small to be seen with the naked eye. By breeding from worms free from these germs, and keeping them separate from those with the disease he proved that the germs were the cause of the disease. By using Pasteur's method of getting germ free worms the silk industry of France became again successful.

Fifteen years later Pasteur made a still more wonderful discovery which pointed out a way by which people might be protected from certain diseases. He was studying chicken cholera, and on returning from a vacation inoculated some chickens with a culture of germs that had stood too long. The chickens were not made sick by the old germs, but the wonderful thing about it was that when they and other chickens were later inoculated with fresh germs, they, alone, were not made sick. They had been made immune.

Now he tried inoculating sheep with anthrax germs that had been weakened in a way somewhat as the cholera germs had been.

There was much doubt and scoffing about his theories so he arranged a public demonstration for the doctors and scientists. Gathering them together Pasteur inoculated forty-eight sheep with the deadly germs of anthrax. Twenty-four of them had previously been treated with the weakened germs for their protection. At Pasteur's invitation his audience returned after two days and found the unprotected sheep dead or dying, while the twenty-four which had received the previous treatment were grazing contentedly in the pasture.

The most picturesque and perhaps the most important chapter in the story of Pasteur's work is the account of the long and finally successful fight he made to make a way of saving those bitten by mad dogs. He and his assistants tried in one way after another to find a method of weakening the germs of rabies as they had weakened the germs of chicken cholera and anthrax to be used in preventing the disease. These germs did not

respond to the same treatment that had been successful with the others.

Every indication pointed to the fact that rabies was a disease of the nervous system. The seat of the trouble seemed to be in the brain and the spinal cord. At last he found that by drying the spinal cord of a rabbit that had had the disease it could be used to inoculate dogs and it would do them no harm. The first that he used had been drying for fourteen days. Then he inoculated the same dog on successive days with material that had been drying thirteen days, twelve days, eleven days, etc., until when it was inoculated with fresh, deadly material that had not dried at all the dog was not hurt by it.

But would the inoculations with dried spinal cords work the same with human beings as they did with animals? It was risky trying such experiments with humans.

But just then while he was wondering whether he ought to take the risk where a human life was concerned a shepherd boy badly bitten by a mad dog was brought to him. He consulted two other doctors, who told him the boy would surely die if nothing was done for him so he applied the remedy that had been successful with animals. The boy recovered from his bites and did not go mad.

Since that time many an otherwise doomed person has been saved from a terrible death by the remedy Pasteur discovered.

While Pasteur was working in France the since famous German doctor, Robert Koch, was learning a great deal about the habits of disease producing germs. Koch is best known for his discovery in 1882 of the germ that causes tuberculosis. He thought for a while that he had also discovered a method of combatting the germs so as to cure the disease, but trial and failure proved him mistaken in that.

Koch is also remembered as having discovered the comma shaped bacillus which causes the terrible Asiatic plague, cholera.

Finding the germ that causes any disease is a long step in advance for then its habits can be studied, and ways for preventing its spread. For example, the cholera germ is spread in the foul drinking water of the Orient. Boiling the water prevents the disease.

One of the greatest services that Robert Koch rendered to the world was to learn scientific methods of making pure cultures of germs and of staining his microscope specimens so that they can be more easily seen. He found one day several different colored

specks on a spoiling piece of boiled potato and on studying these specks with his microscope found a different kind of bacteria in each. He concluded that each speck was a colony started from a single germ falling on it from the air. This led to the method now used of getting pure cultures on a dish of some solid substance like gelatine mixed with broth or some such food for the bacteria. Bacteriology has grown from the start Koch gave it into a great science.

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## BIRGE'S WORK ON THE GENERAL PHYSICAL CONSTANTS.

By Duane Roller,

*University of Oklahoma, Norman, Okla.*

Of the greatest importance to all physical scientists is the recent paper on "Probable Values of the General Physical Constants,"[1] in which Professor Raymond T. Birge, of the University of California, Berkeley, summarizes his extensive and remarkably painstaking investigations of the values of the constants of astronomy, physics and chemistry. Because of the immense scope of this work, Professor Birge's paper, although it covers 73 pages, is itself necessarily a digest. Consequently in the present brief review, it is hardly possible to do more than mention a few of the essential facts and striking ideas brought to light in the original paper. I will, so to speak, give some of the condiment, with only a little of the meat, in the hope that the reader seeking real nourishment will resort to the original article.

There has been a great need for this critical study of the numerical magnitudes of the various universal constants. Some of the most important results of physical science are embodied, directly or indirectly, in these values; yet one finds, among other things, that the values in general use show a surprising lack of consistency.

Beginning with the constant whose value depends least on other constants, Professor Birge determined the probable value of each constant from available data, using, whenever possible, formulas not involving approximations. Whenever it seemed necessary, the constant was recalculated by analytic methods, usually by the method of least squares. An endeavor was made

[1]Physical Review Supplement, 1, pp. 1-73 (1929). This new quarterly, which is published under the auspices of the American Physical Society, is intended to provide comprehensive, authoritative and timely discussions of the problems of physics, presented when possible in such form as to interest and inform those who are not specialists in the subjects under discussion.

also to obtain the *probable error* of each constant. A knowledge of the probable error is often quite as important as the constant itself; yet, ordinarily, published lists of constants contain no precise estimate of error.

The somewhat detailed discussions of the several "principal constants and ratios" include the following interesting comments. The values of some of these constants, as given by Birge, appear at the end of this review:

(a) Speed of light in vacuum ($c$). Michelson's investigation (Astrophys. J. 65, p. 1, 1927) so far surpasses in accuracy any of the preceding that it alone need be considered. It has yielded a value for $c$ that may be considered as more or less permanently established. Rosa and Dorsey (Bur. Standards, Bull. 3, pp. 433-604, 1907) have made the best determination of the ratio $c'$ of *cgs* electrostatic to *cgs* electromagnetic units, their work showing that $c$ and $c'$ are equal, within limits of error. According to the electromagnetic theory of light, the ratio $c'$ constitutes an indirect determination of $c$, and the value obtained by Rosa and Dorsey is found to be more accurate than any direct determination of $c$, up to the time of Michelson's latest work.

(b) Newtonian constant of gravitation (G). Heyl's determination (Proc. Nat. Acad. Sci. 13, p. 601, 1927) is so much more accurate than any previously available that it is likely to remain unchanged for some time to come.

(c) Relation of international to absolute electrical units. At the time of their adoption, in 1908, the international units, which are defined in terms of definite physical standards, were of course identical with the corresponding absolute electrical units. However, it is now known that they disagree. The exact evaluation of the relations between them is very difficult experimentally, especially since there is no one official standard, each national laboratory having its own international standards. Because of this unsatisfactory situation, a move is being made toward the adoption of the absolute electrical units as standards, but for the purpose of correcting work already done, it is necessary to know the relations between the two systems. The values of the ampere in the two systems are almost identical but the international ohm definitely differs from the absolute ohm by about 1 part in 2000. Because experimental physicists have usually ignored these distinctions, many slight changes in published results have been necessary.

(d) Normal atmosphere ($A_n$). Birge prefers to define the

normal atmosphere as the pressure exerted by a column of mercury 76 cm high, of normal density (0° C, $A_n$), and subject to normal acceleration of gravity. In determining the normal density of mercury, an approximate value of $A_n$ can be used, because of the small variation of the density with pressure. The International Commission of Weights and Measures and the *International Critical Tables,* on the other hand, define $A_n$ as the pressure due to a column of mercury 76 cm high, of density 13.5951 $g \cdot cm^{-3}$, under normal acceleration of gravity. The latter definition makes $A_n$ a conventional constant, with therefore no probable error. Birge points out that no temperature is specified in this latter definition and that the word "mercury" is superfluous; thus no simple method is afforded for reducing to standard atmospheres an actual barometer reading made at an actual observed temperature.

(e) Mechanical equivalent of heat (J). The most accurate direct determination is that resulting from the work of Laby and Hercus (Phil. Trans. A 227, p. 63, 1927), in which a continuous flow calorimeter was used. The best indirect evaluation, obtained by determining the electrical equivalent of heat (J′), and taking due account of the discrepancy existing between international and absolute electrical units, is that resulting from the work of Jaeger and Steinwehr (Ann. Physik 64, p. 305, 1921).

(f) Electronic charge ($e$). In the sense that so many important constants have values that depend directly on the value of the electronic charge, the latter may be considered the most important of the general constants. A constant of such importance should be determined in many different ways and by many different persons; yet, until recently, the oil-drop method was the only precision method known and the work by this method was carried out by one man—Millikan. Fortunately, Millikan's investigation represents a masterpiece of experimental technique carried out over a long period of time with the greatest attention to possible causes of error. Millikan agrees that the final value of $e$ obtained by the oil-drop method is now subject to two new corrections, rendered possible by the newest value of $c$ and by our present knowledge of the distinction between international and absolute electrical units. Recently there has been devised an entirely new method for obtaining $e$, based on X-ray measurements, that bids fair to become more accurate than the oil-drop method, although the results published so far are less reliable than the oil-drop value.

## A LIST OF SELECTED PHYSICAL CONSTANTS

| | |
|---|---|
| Velocity of light | $c = (2.99796 \pm 0.00004) \times 10^{10}$ cm·sec$^{-1}$ |
| Gravitational constant | $G = (6.664 \pm 0.002) \times 10^{-8}$ dyne·cm$^2$·g$^{-2}$ |
| Liter | $l = 1000.027 \pm 0.001$ cm$^3$ |
| Volume of perfect gas (O° C,$A_n$) | $v_n = (22.4141 \pm 0.0008) \times 10^3$ cm$^3$·mole$^{-1}$ |
| International ohm ($=p$ abs−ohm) | $p = 1.00051 \pm 0.00002$ |
| International ampere ($=q$ abs−amp) | $q = 0.99993 \pm 0.00005$ |
| Atomic weight of oxygen | $O = 16.0000$ (definition) |
| Atomic weight of hydrogen | $H = 1.00777 \pm 0.00002$ |
| Normal atmosphere | $A_n = (1.013249 \pm 0.000003) \times 10^6$ dyne·cm$^{-2}$ |
| Ice point (absolute scale) | $T_o = 273.18 \pm 0.03$°K |
| Mechanical equivalent of heat | $J_{15} = 4.1852 \pm 0.0005$ abs − joule·cal$_{15}^{-1}$ |
| Faraday constant | $F = 96489 \pm 7$ abs − coul·g − equiv$^{-1}$ |
| Electronic charge | $e = (4.770 \pm 0.005) \times 10^{-10}$ abs − *es* − units |
| Specific electronic charge (spectroscopic) | $e/m = (1.761 \pm 0.001) \times 10^7$ abs − *em* − unit·g$^{-1}$ |
| Specific electronic charge (deflection) | $e/m = (1.769 \pm 0.002) \times 10^7$ abs − *em* − unit·g$^{-1}$ |
| Planck constant | $h = (6.547 \pm 0.008) \times 10^{-27}$ erg·sec |
| Ratio of *es* to *em* units | $c' = (2.9979 \pm 0.0001) \times 10^{10}$ cm·sec$^{-1}$ |
| Acceleration of gravity (normal) | $g_n = (980.616$ cm·sec$^{-2}$ |
| Density of mercury (O° C, $A_n$) | $D_n = 13.59509 \pm 0.00003$ g·cm$^{-3}$ |
| Electrochemical equivalent of silver | $E_{Ag} = (1.11805 \pm 0.00007) \times 10^{-3}$ g·abs − coul$^{-1}$ |
| Wave-length of red cadmium line (15°C,$A_n$) | $\lambda$(Cd) $= 6438.4696$ I.A. (definition of I.A. unit) |
| Avogadro's number | $N_o = Fc/e = (6.064 \pm 0.006) \times 10^{23}$ mole$^{-1}$ |
| Gas constant per mole | $R_o = v_o A_n / T_o = (8.3136 \pm 0.0010) \times 10^7$ erg·deg$^{-1}$·mole$^{-1}$ |
| Mass of electron (spectroscopic) | $m_o = \dfrac{e}{c(e/m)_{sp}} = (9.035 \pm 0.010) \times 10^{-28}$g |
| Mass of electron (deflection) | $m_o = \dfrac{e}{c(e/m)_{defl}} = (8.994 \pm 0.014) \times 10^{-28}$g |
| Mass of hydrogen atom | $M_H = H/N_o = (1.6617 \pm 0.0017) \times 10^{-24}$g |
| Mass of proton | $M_P = (H\text{-}m)/N_o = (1.6608 \pm 0.0017) \times 10^{-24}$g |

(g) Specific charge of electron ($e/m$). Of the five distinct methods for measuring $e/m$, the three most accurate are based on: (1) deflection of electrons in electric and magnetic fields; (2) Zeeman effect; (3) fine structure and relative wave-lengths of hydrogen and singly ionized helium spectral lines. The first, or deflection, method yields a value for $e/m$ based on the behavior of electrons in free space, whereas the last two, spectroscopic, methods are for electrons inside an atom and involve the quantum theory of atomic structure. It is a very startling and fundamentally unsatisfactory fact that a real discrepancy exists between the value of $e/m$ obtained by the deflection method and those obtained by the spectroscopic methods. Possible explanation of this discrepancy are that the $e/m$ of an electron really is less when it is inside an atom than when it is outside, that there is some general error in the quantum theory of atomic structure, or that there is some unknown error in all the deflection experiments. Whatever the explanation, it is at the present time necessary to assume two different values of $e/m$, one to be used in atomic structure, and the other for free electrons.

Birge gives the values of some 130 constants, calculated on the basis of data available to him on January 1, 1929. The constants on the preceding page have been selected from his list.[2]

[2]The complete list of constants, printed on handy reference cards, can be purchased from the Physical Review Supplement, University of Minnesota, Minneapolis.

## A CONVINCING PROOF.

By J. C. Packard,

*Brookline, Mass.*

The crowning glory of any scientist is the ability to prophesy. The reputation of Einstein was enhanced a hundredfold when it was found that a ray of light in passing by the sun is actually "bent out of its course" in exact accordance with his predictions. An experiment that "works" and justifies the theory advanced by the teacher is the joy and delight of the average school boy. He knows now what he half believed before. The following experiment illustrates the point.

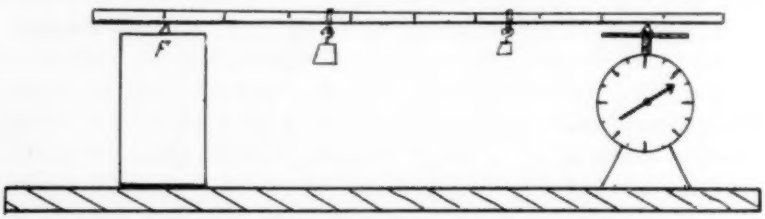
### Apparatus.

A wooden bar, five feet or more in length and one square inch in cross section, graduated into feet and marked with figures large enough to be seen across the room. Two small triangular prisms with sharp edges. A wooden frame, or a box of some sort,

to support one end of the bar. A dial balance, reading to twenty-four pounds or more, to be found amongst the kitchen utensils at almost any hardware store. A 2-lb. weight and a 1-lb. weight.

### Experiment.

Assemble the apparatus as in the figure, the dial facing the class. Remove the weights and, with the bar in place, adjust the balance to zero by means of the knurled head to be found beneath the scale pan. This disposes of the weight of the bar.




Cover the dial with a card to conceal its indications. Replace the two-pound weight and compute the reading of the balance, using F as a fulcrum and making use of the law of moments. Write the result on the board. Remove the card and ask the class to verify your "prophecy" by observing the position of the pointer on the scale. There is no dodging the answer: it is not to be found in a text book but is handed out to the class by Dame Nature herself! Did you hit it? Add the second weight and try again.

Vary the conditions as widely as possible and have the students compute answers, concealing the readings in each case until the probable result has been decided upon, and then compare notes.

As a final experiment, hang an extra weight at the left of the fulcrum and bring in the weight of the bar, by adjusting the balance to zero with nothing but the prism resting upon it. Test again.

It is a great game and decidedly instructive, in more ways than one.

### Auxiliary.

Show the Boy Scouts how to make a Dutch Steelyard out of a fishpole or an Alpine stock, for weighing fish caught away from camp when no scales are available. If the weight of the pole is unknown, it can of course be determined upon arrival at home and the exact weight of the fish, in pounds, can then be easily deduced from the data at hand. An interesting application of the principle of moments.

## THE NECESSARY SKILLS EMPLOYED IN THE SOLUTION OF SIMPLE EQUATIONS.

By JOHN CROFTS, *Lindblom High School, Chicago,* AND WILL CLARK, *Crane Jr. College, Chicago,*

1. Involving Two term equations.
   (a) $11x=286$. Solving for x. Dividing both terms of an equation by the same number does not change its value. This will be referred to as the division law in the remainder of this outline. 1 skill
   (b) $27x=221.4$. The division law; division of a decimal by a whole number. 2 skills
   (c) $13x=479$. Quotient comes out fractional; division law. 2 skills
   (d) $8.4x=168$. Division of a whole number by a decimal; division law. 2 skills
   (e) $1.35x=911.25$. Division of a decimal by a decimal. Division law. 2 skills
2. Involving more than two terms in the equation.
   (a) $5x+3x=96$. Addition of two like terms in the first member; then the division law. 2 skills
   (b) $13x-4x=117$. Subtraction of like terms in the first member; then the division law. 2 skills
   (c) $2.6x-.9x=28$. Addition of like terms in the first member; addition of decimals; division law; fractional remainder. 4 skills
   (d) $16.5x-4.2x=123$. Addition of like terms in the first member; addition of fractions; division law; division of a whole number by a decimal. 4 skills
   (e) $4x+8x+6x=90$. Addition of three terms of the same sign in the first member; the division law. 2 skills
   (f) $18x-5x-2x=198$. Addition of two minus quantities; addition of a positive and a negative quantity (knowledge of signs); then division law. 3 skills
   (g) $25x+x-8x=98$. Addition of two positive quantities; addition of two quantities of unlike sign; division law; reducing fractional remainder. At least 4 skills
   (h) $10-x=3$. The addition of a negative number to each member of an equation $(-10)$; the multiplication—or division—of both members of an equation by $-1$; the division law. 3 skills
   (i) $-8-x=12$. The addition of a positive number to both members of an equation $(+8)$; the multiplication, or division, of both members of an equation by $-1$; the division law. 3 skills
3. Involving Transposition: Addition of numerical term, or addition of numerical and literal terms to both members of an equation.
   (a) $x-10=5$. Addition of a positive term to both members of an equation. (Involves addition of terms of like sign and terms of unlike sign). 2 skills
   (b) $x-40=-8$. Addition of positive term to negative term. 1 skill
   (c) $5x=32-3x$. Addition of a literal quantity with a numerical coefficient to both members of an equation; then the division law. 2 skills
   (d) $5x-70=-2x$. Addition of a literal quantity with a numerical coefficient to both members of an equation; the addition of a numerical quantity to both members of an equation; and the division law. 3 skills
   (e) $5x-8=-5x-3$. The addition of a literal quantity with a numerical coefficient to both members of an equation. (The addition of $+5x$ to $+5x$ is one skill, the addition of $+5x$ to $-5x$ is a second

skill); the addition of a numerical quantity to both members of an equation (+8 to both members of the equation) division law. 4 skills

(f) $2x-14-5x+4=0$. The addition of a positive and negative literal monomial; the addition of a positive and negative numeral; the addition of $-10$ to zero; and the division law. 4 skills

Transposition: Subtraction of numerical and literal terms from both members of an equation.

(a) $x+13=25$. Subtraction of a positive number from a positive number. 1 skill

(b) $x+13=-2$. Subtraction of a positive number from a positive number; subtraction of a positive number from a negative number. 2 skills

(c) $3x+11=32$. The subtraction of positive numbers; the division law. 2 skills

(d) $4x=60-x$. The subtraction of positive and negative literal quantities (2 skills); and the division law. 3 skills

4. Equations Involving Parenthesis.

(a) $3x-(x-4)=14$. Changing all the signs within a parenthesis when the parenthesis is preceded by a minus sign; addition of positive and negative literal quantities; addition of positive and negative numbers (+4 and −4); the division law. 3 skills

(b) $3+2(x-3)=1$. The multiplying of a parenthesis by a numerical coefficient $2(x-3)$; the removal of parenthesis without changing the signs within the parenthesis when preceded by a plus sign; the adding of numbers of unlike signs (+3 and −5); the addition of a number to both members of an equation (+3 to −3 and +3 to +1, two skills); the division law. 6 skills

(c) $5(x-1)=30$. The multiplication of a parenthesis by a number $5(x-1)$; addition of a +number, (+5), to a −number, (−5) and addition of a positive number to a positive number (+5 and +30); the division law. 4 skills

(d) $7(3x-2)+11=60$. Multiplication of a parenthesis by a numerical coefficient $7(3x-2)$ the addition of numbers of unlike signs (−14 and +11); the addition of a number to both members of an equation (2 skills); the division law, (21x). 4 skills

(e) $11a-(4a-9a)+(6a-a)=42$. Changing all the signs within the parenthesis when the parenthesis is preceded by a − sign, $-(4a-9a)$; the removal of a parenthesis without changing the signs within the parenthesis when preceded by a plus sign; the addition of positive literal quantities, (+11a and +9a and +6a); the addition of positive and negative literal quantities, (+26a and −4a and −a); the division law. 5 skills

(f) $4(2x-5)+15=3(x+10)$. The multiplication of parenthesis by a positive number; the addition of negative literal numbers to both members of an equation, (−3x); the addition of positive and negative numbers, (−20 and +15); the addition of a positive number to both members of an equation, (+5 to −5 and +5 to +30); the division law, dividing by 8. 5 skills

(g) $12y-2(4y-7)-16=0$. The multiplication of a parenthesis by a number, (2); the removal of a parenthesis preceded by a minus sign, (8y−14); the addition of positive and negative literal quantities, (12y and +8y); the addition of a positive and a negative number, (+14 and −16); the addition of a positive number to both members of an equation; the addition of zero and a number, (0 and −2); the division law. 7 skills

(h) $9y-3(2y-4)=2(5-4y)+2$. The multiplication of a parenthesis by a number; the changing of the signs within a parenthesis when preceded by a minus sign; the removal of a parenthesis without changing the signs when preceded by a positive sign; the addition of positive and negative literal quantities, ($9y$ and $-6y$); the addition of a literal quantity to both members of an equation, ($+8y$); the addition of two positive numbers, ($+10$ and $+2$); the addition of a negative number to both members of an equation, ($-12$); the division law. 8 skills

(i) $(4y-3)(y+2)-4(y-3)(y+3)=35$. The multiplication of a binomial by a binomial, $(4y-3)(y+2)$ including the laws of signs for multiplication of a parenthesis by a number, (4); the removal of a parenthesis when preceded by a minus sign; the removal of a parenthesis when preceded by a plus sign; canceling like term with opposite signs in the same member of the equation; combining numerical values in the same member of the equation, ($-6$ and $+36$); adding a number to both members of an equation, ($+30$); the division law. At least 9 skills

5. Involving Fractional Equations. (Not quadratic).

(a) $\frac{1}{3}x=4$. Multiplying both members of the equation by 3. Division law. 1 skill

(b) $x/5=3/5$. Multiplication law. Division law. 2 skills

(c) $x/2+x/3=5/3$. Selection of a common multiple of the denominator; multiplying each term by it; factoring numerator and denominators; adding like terms; division law. 5 skills

(d) $3+1/x=7/x$. Selection of a literal common multiple; multiplying by the common multiple; subtracting a numerical term from both members of the equation; division law. 4 skills

(e) $3/2+5/3x=4$. Selecting a common multiple having both literal and numerical terms; multiplication by the common multiple; canceling numerators and denominators of like terms; subtraction of a literal term from both members of the equation; subtraction of a numerical term from both members of the equation; division law. 6 skills

(f) $\frac{x+1}{x-1}=\frac{a+b}{a-b}$ Clearing of fractions, in this case two laws of signs in multiplication; the multiplication of a literal quantity by a literal quantity; the addition of a positive literal quantity to both members of an equation, ($+a$ and $-b$); the addition of terms with like signs, ($-bx$ and $-bx$); the addition of terms of unlike signs, ($+ax$ and $-ax$); the division of both members of the equation by $-2b$; cancellation of like terms in numerator and denominator. At least 9 skills

| Summary of Skills Employed in Solving Simple Equations. | Classification |
|---|---|
| 1. The Law of division as pertaining to dividing out coefficients in solving for the unknown. | |
| a. Both positive signs | Arith. and Alg. skill |
| b. Both negative signs | Arith. and Alg. skill |
| c. Unlike signs | Arith. and Alg. skill |
| d. Decimal by whole number | Arithmetical skill |
| e. Whole number by decimal | Arithmetical skill |
| f. Decimal by decimal | Arithmetical skill |
| g. Division of whole numbers with a remainder | Arithmetical skill |
| 2. Addition of like terms, —integral | Arithmetical skill |

| | |
|---|---|
| 3. Addition of like decimal terms | Arithmetical skill |
| 4. Subtraction of like terms, −integral | Arithmetical skill |
| 5. Subtraction of like decimal terms | Arithmetical skill |
| 6. Adding numerical terms to both members of an equation | Arith. or Alg. skill |
| 7. Adding literal terms to both members of an equation | Algebraic skill |
| 8. Adding zero to any number | Arithmetical skill |
| 9. Subtraction of a numerical term from both members of an equation | Arith. or Alg. skill |
| 10. Subtraction of a literal term from both members of an equation | Algebraic skill |
| 11. Multiplication of a parenthesis by a positive monomial | Arith. or Alg. skill |
| Note: Fractions preceded by a minus sign obey the rule for parenthesis | |
| 12. Changing signs within a parenthesis when preceded by a minus sign | Arith. or Alg. skill |
| Note: Fractions preceded by a minus sign obey the rule for parenthesis. | |
| 13. Clearing fractions. | |
| a. Find least common denominator of denominators | Arith. or Alg. skill |
| b. Multiply every term by the least common denominator | Arith. or Alg. skill |
| c. Reduce terms | Arith. or Alg. skill |
| 14. Multiplication of two binomials | Arith. or Alg. skill |

## WHY IS IT CALLED A CENSUS?

Does a census bear any relation to a censor, and, if so, why? In 1930, starting May 1st, the U. S. Government conducts its decennial counting of the country's population. The first such census was taken in 1790; there has been a census every ten years ever since.

In Roman times, in the days of antiquity, the census was taken in order to apportion taxes. The taker of the census was called a censor. He counted the people, valued their property, and, at the same time, officially inspected their morals and conduct. It is from the latter part of the ancient censor's duties that we get our modern use of the word censor, as meaning "one who acts as an overseer of morals and conduct."

Census, as a word, is thus closely related to censor. According to Webster's New International Dictionary, both words come from the same Latin verb, "censere," meaning to value or to tax. The 1930 Federal Census is to be an enumeration of population, irrigation, drainage, distribution, mines, and unemployment. It is expected that eight months will be consumed in the work.

The U. S. Census also determines the apportionment of the House of Representatives, which depends on the population. This reapportionment has just been effected by an act of congress—a belated action, for there has been no reapportionment, according to changes in population, since 1910. Some states will gain, some will lose, in representation, with the results of the 1930 census.

## PRINCIPLES OF INTEREST APPLIED TO BIOLOGY.

By George O. Hendrickson
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A young teacher in Biology was approached one day by one of his students with the question, "Will there ever be anything interesting taken up in this course?" The instructor replied, "Do you want me to stand on my head?" The student went to the office of the Principal, told his side and received a drop slip for the rest of the term. The instructor was angry, and demanded to know why everything should be "sugar-coated" in that school. The Principal pointed out that though the student had not approached his teacher tactfully, the instructor should not have replied with sarcasm. The Principal said that he expected the teacher to gain the interest of his students or seek a new position. This wakened the young man to his senses and he wanted to know what interest is. They agreed shortly that proper interest is not in the enjoyment of frivolous loafing, with "sugar-coated spoon-feeding," or any other despised trick affair. It is not a method of teaching nor the end in itself. Interest was defined as a mental state accompanying an impulse or stimulus that is strong enough to insure activity until a certain end is attained. It is a quality of mind accompanying responsive activity.

The young man found upon reading good authorities in teaching methods that spontaneous activity is generated by the touching of a natural impulse. He determined that curiosity was one natural impulse that might be employed to start interest in classification. It seemed that all his students loved Nature though they said they disliked Biology as he had taught it. After hearing them wonder at the marvelous planning required to keep all the laws of Nature in operation, he decided to make an appeal to the instinct of wonder. To his surprise the lazy students actually enjoyed working out new and simple keys to certain groups of plants and animals. The instinct of creativeness had been touched, also. The appeal to ownership made a collection of specimens a live issue. Because his students liked to compete in the finding of specimens the natural impulse of rivalry was used to develop interest in gaining more knowledge. A few visits with his pupils proved they were desirous of advancing in education. Each wished to be prominent in some way, some day. Each was conscious of the futility of living to himself alone. Self-advancement, love of prominence and altruism were

impulses to be reckoned with in the teaching of pure science. Interest seemed higher when the class and the teacher had similar viewpoints. Sympathy must be touched. The students were interested in great systematists, and they wished to learn how they became famous. Imitation was appealed to in striving for this power. He found his students staying together in certain viewpoints, and hence gregariousness must be guided in his teaching. And last, but not least, among the chief impulses to be dealt with in education he consented to acknowledge the love of approbation. It did not waste time to stop to approve of good work in collections. It was profitable to commend the good as well as to point out the bad in pupils' work. Thus he provided for many natural impulses in the unit of classification. Each of the cherished facts and principles in Biology could be made to appeal to one or more instincts, and the interest in the subject grew.

But instincts were not all of the matter in arousing interest. If new terms were to be introduced there must be a felt need for them. The word calyx was remembered well because it was used in the presentation to show its function in the flower of an apple tree. When a real problem was before the class new terms were learned more rapidly. Several were confused in the names of flowers which they admired. The flowers differed in petal characteristics. The problem of distinguishing them required detailed knowledge concerning petals. Best thinking was provided by means of problems which first provided use for knowledge in thinking. When problems did not arise concrete applications were stimulating to interest. Problems based upon concrete situations such as the students would meet outside of school promoted the best interest. Pupils wished to know why flowers were given their names, why bees were at the flowers, what the cup-plant did with the water in its cupped leaves and why some insects were colored more gaily than others. When the teacher and pupils could not find problems the principle of having the learners look for concrete applications was found quite successful. It was not so stimulating to supply concrete illustrations, himself, of the application of use of the facts. It proved very interesting to the class to have several members discover how the knowledge of the structure and life history of wheat rust is used in its control when this was found as a partial solution of the major problem of how the wheat crop may be increased.

At first, it seemed that when sufficient instincts had been appealed to and need aroused through problems, the interest would come along in high form. But he found certain guidance requisite within the course. If the knowledge taken up for the moment was within the course interest tended to be maintained and if it was closely related to the other parts more interest accrued. In the problem of how to distinguish between yarrow and tansy the problem of why the tansy has an odor that is so pungent arose. This forward connection led to a point to be used in distinguishing them. The pupils observed that each had a characteristic odor. This led to the problem of how to distinguish them when they were pressed. These several problems came up at the same time. Hypotheses such as attractiveness to man, disagreeableness to grazing animals, and attractiveness to insects were suggested in relation to the odor of tansy. The instructor as chairman decided to have the problems settled one at a time. It was decided temporarily that leaf differences would help in distinguishing pressed specimens. Then the class went back to the problem of distinguishing the plants in the field and took up the other two problems later. If a problem arose within another it seemed best to work interest up to a point of suspense through development of hypotheses by all members, and then to go on with the original problem. It was found well to precede microscopic work with larger details. The new topic of internal structure of a frog had some relations with external parts seen previously, and had some relations with the functions of the animal as a whole. Each student, to gain interest, had to see the connections between the old and the new topics. Often, if the new topic had no relation to an old topic it had little or no immediate interest.

Despite the instructor's firm belief that he must teach only facts and principles, he found references to literature and other subjects were discussed among his students. It did not help to ridicule the poet as a scientist. "Among the murmuring pines and hemlocks," gave the teacher a new thrill in the conifers though it did not seem scientific to speak of the pines as murmuring. The awakening instructor decided that references to other courses, if in keeping with the subject matter at hand, did add interest. The students read scientific articles in newspapers and seemed unduly interested in them. So another principle, that interesting persons and news within a subject are sources of interest, was found. His accidental mention one day

of the difficulty in determining the species of asters seemed to confirm the principle that people are interested in the hard problems of others. He had not intended to mention any species of asters, but the class seemed to wish to know more than the genus name; and his insistence that they were too difficult for even himself in many cases served as a challenge to several pupils to know the species. For some time he had talked conservation of flowers, discussed the application, but never had seen it applied. Perhaps the teaching of principles of conservation and practice should go together, he decided. It might be well for the class to go flower hunting to obtain bouquets that could decorate their own rooms. At first it seemed very childish to the dignified instructor, but he noticed the principles were remembered longer. The rare flowers were conserved. Interest was aroused, thought followed and proper activity was brought out in flower conservation.

His experience with the interest in conservation led him to believe that inductive thinking in his class was of great value. He decided that a problem must exist in the learner's mind as the beginning of thought. The teacher might raise the question, but the pupil must accept it as his own problem. Although the principle might be evolved by the learner, the principle required testing. Continued creative thinking called for a second new problem where the pupils planned and managed all details. The instructor decided to test his students on conservation by taking them to a place which they had not visited before and where there were several new species of rare flowers. At this location he asked the pupils to pick a bouquet for the classroom. In this test he noticed several watching him and he thought they might be looking for clues. But by avoiding nods, pauses, peculiar tones and other differing signs, the students were kept at work. Such peculiarities would give away the answers. When a student was in doubt about plucking a certain flower, and expressed a desire for knowledge, he asked a question which pointed toward the proper conclusion. It was better to direct thought by questions that raised continued ideas than to give the information to the student.

Upon checking his results during several terms it seemed that the employment of skills based upon these principles were not all of the secret of success in securing interest. A student told him that his interest was partly due to the teacher's enthusiasm, sincerity, and initiative in the subject. The teacher was not aware that his personal traits played such a large part in the

endeavor to secure interest. He had prided himself on not being a stage performer, a tailor's model and an exemplary saint. Personality, he thought, he did not possess, and he had wished to be careful to omit it. In time it developed in his study that sympathy was a large element of his personality that generated interest of the permanent type. Patience, courtesy, friendliness and discretion seemed to be comfortable in practice and increased his interest in teaching. Teaching had seemed an unnatural affair. With the development of personality traits it seemed the most natural procedure ever conceived. Personality became a large affair in its new meaning and absorbed character which he had insisted was not a part of the teacher's equipment. Through his friendliness he found that his moral traits were under discussion among the students and as they saw the traits revealed their attitudes and actions were guided and influenced. He decided that fairness, with firmness and tolerance, dependability and self-control were factors in personality that he should strengthen because of the influences on permanent interest. The optimism of his views and general control of the class aided in keeping up the general atmosphere of the course. Tact and judgment prevented many tangential, disinteresting and disconcerting lines of thought. His loyalty and cooperation with the class, the school and the people of the community reacted to establish interest of more permanent nature. Altruism had a place in the list of personality traits although he had considered himself very candid in saying that he taught for money, only. Personal appearance, voice, poise and humor were not the large factors of service in securing interest. His attempts to use his personal traits with the other skills in his methods seemed to change the students from mere grade getters, in his opinion, to genuine seekers of knowledge.

The enumeration of and attempts to develop personal traits did not end the need of discovering principles underlying personality as a factor in teaching. Ideals were the goals in teaching. Permanent retention and activity were merely aids to develop ideals. Ideals could not be preached to the pupils and secure acceptance for real future activity. Ideals grew out of interest and interest led to ideals. Ideals were thus taken from one individual to another by the second observing them in the first in activity.

The first aim of this young man, to train many people in the

love and appreciation of plants and animals, soon appeared to be only a small portion of his job. As his students came back to him it became evident that he was not teaching for the term alone. Their mention of seeing objects and phenomena taught in the class set up a new aim in the young teacher's mind. Not only was certain knowledge to be retained permanently, but interest in its application to obtaining further knowledge was developing; and it might be developed further. The first principle observed by him was that high interest in daily class work had developed some permanent interest. Motivation to the end of the course by keeping alive the feeling of need was of value. His accidental, possibly boastful, praise of one student's ability in graftage to a townsman resulted in an invitation to top-work an undesirable plum tree. This showed that students might gain permanent interest if they could receive recognition of special ability in work outside the course which in turn appealed to love of prominence, altruism and self-advancement in the student. Ideals of real workmanship, of love of truth and right thinking were determiners of outside activity as sentiments woven from responses to instincts. These ideals were developed in connections between the subject matter of the course and the ideals. Skills and abilities of certain kinds were requisite in the establishment of ideals. Constant appreciable progress in the growth in skills seemed necessary. Unsolved problems and leads to new knowledge caused students to look forward and ask for more knowledge, which if seen to be equally interesting and worthwhile, operated in increasing interest rather than in dissatisfaction and despair.

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## NEW BASE MAP OF CALIFORNIA.

The Geological Survey, Department of the Interior, has just published a new base map of California, which completes the series of state maps on the standard scale of 1:500,000. The map is printed in two sections, each measuring 44 by 64 inches, and in two colors—black and blue. The features shown include state, county, and township lines, Indian reservations, national monuments, railroads, streams, cities, and villages. As on some of the other more recent maps of this series, stream names are shown in blue, which lightens the tone of the map. California includes within its boundaries the highest and lowest points of land in the continental United States. Mount Whitney is 14,496 feet above sea level, and a point in Death Valley is 276 feet below sea level. The difference in altitude between these two points, which are only 86 miles apart, is therefore 14,772 feet, or about 2.8 miles.

## FALLACIOUS IDEAS.

By J. H. Cloud,[1]

*Oklahoma Agricultural and Mechanical College, Stillwater, Okla.*

Anyone who has observed smoke issuing from chimneys will remember that on some days the smoke rises, on other days it travels horizontally with the wind, and on others it settles quickly to the ground. To one who is conversant with atmospheric changes and who understands the buoyant forces of fluids, these different motions are exactly as would be expected. Furthermore, these motions afford some indication of the density of the air at the time of observation. When the air contains much water vapor, which is lighter per unit volume than dry air, it is less dense than when little vapor is present. On these days smoke is likely to fall.

The average person does not distinguish clearly between these up and down forces. It is often said that the "air pushes the smoke down." I have heard the older generation predict rain because the "air is so heavy that it pushes the smoke down to the ground." This same reasoning would lead one to believe that rare air by its failure to push would allow a balloon to rise more rapidly than dense air.

Just this morning I read in the newspaper a letter from a vacationist who is spending a few days in the high altitudes of Colorado. He was describing to his readers the natural hazards in golf in that country. His statement is: "The air is so rare that the golf ball might continue to float if it were once driven above the tree tops." Here the writer loses sight of gravitation and supposes, as he has heard concerning the smoke, that it is the air which pushes the golf ball down to the earth. Hence, if the air were very rare, it might not be able to push the ball down and the ball would continue to float.

Mothers call to their children to "come in out of that damp heavy atmosphere." To one who will study this a few minutes, it is obvious that dampness keeps the atmosphere from being heavy.

Some of these mothers are college graduates, as is also the vacationist who wrote the letter for the paper. Doubtless these fallacious ideas still persist because of poor teaching and because

[1]Dr. Cloud is professor of physics and head of the department in the Oklahoma Agricultura and Mechanical College. His research contributions to physics include measurements of wavelengths in the infra-red, reflection of light from solutions, and measurements of the intensity of sound.—D. R.

of vague and erroneous statements in textbooks. Many of these misleading statements are still found in present day textbooks. Texts on physical geography state that the "air near the equator is heated, rises, leaving a vacuum and then the cooler air rushes in to fill up the vacuum." One text in physics tries to explain convection in the hot water heating system of houses by a similar statement. This argument puts the cart before the horse; substitutes effect for cause. The student gets the idea that the air or the water rises because it is hot. He should be made to understand that it is the gravitational pull on the colder more dense fluid which pushes the less dense warmer fluid upward.

In this intelligent community wives of college professors complain that "the houses are so poorly built that moisture comes through the walls," in the cold winter weather. This quotation is the common explanation for the so-called "sweating" of houses. The real explanation is that the open gas stove, so common in this part of the country, creates moisture by chemical action in the flame. When this moisture, thus turned loose in the room, comes against a cold outside wall or ceiling, it is chilled to the dew point and condenses into water drops on the wall. Thus the wall of a cold room "sweats" in the winter for exactly the same reason that a pitcher of ice water "sweats" in the summer; another fallacious idea due to poor teaching and incorrect statements in textbooks.

One text on physiography explains that the force of gravitation between two masses varies directly with the product of these masses and inversely as the square of the distance between them; and then states that "even though the mass of the sun is much greater than the mass of the moon, the moon is so much nearer the earth than the sun is, that the gravitational force of the moon is greater than that of the sun." Hence the moon causes larger tides on the earth than does the sun. This last statement is true but it is not because of the argument which precedes it. Anyone with a knowledge of high school algebra, may in a few minutes, substitute the respective masses and distances in the gravitational law and show that the sun's attraction for the earth is about one hundred and seventy-five times as great as that of the moon.

The pressures which cause the flow of fluids in siphons are wrongly stated in some of the older textbooks of physics, the common error being the statement that the pressure in the tube at the level of the surface of the liquid in the basin is atmos-

pheric pressure minus the weight of the column of liquid above it.

Recently we were persuaded to adopt a different textbook in household physics. The book had passed through a second edition and should have been reasonably free from typographical errors. However, we find such statements as: "To melt one gram of ice requires 540 calories." "The watt is the unit of electrical energy." "The watt-hour is the unit of electrical power." In discussing the merits of various types of heating plants, the hot-air system is condemned because "the air which has been burned in this way is devitalized." No suggestion is given as to what is meant by burned or devitalized air.

After correctly stating the gas laws, emphasizing accuracy and illustrating precision by means of the ice calorimeter, the author proposes the following problem: "What is the increase in volume in 10 $cm^3$ of air when heated from 70 degrees Fahrenheit to 430 degrees Fahrenheit?" The problem is intended for college girls of the sophomore year who have presumably solved similar problems in freshmen chemistry. The author solves it as follows: "10x360x.002 = 7.2 $cm^3$." The correct answer is 6.3 $cm^3$, making an error of 14 2-7%.

Three college texts selected at random from the stacks in our library were found to define mechanical advantage of a machine as "the ratio of the weight lifted to the power applied." Two of these three texts take pains later to state that "power as here used does not mean the rate of doing work." The correction comes too late. The mischief is done when the student learns that mechanical advantage is the weight divided by power. These same books properly define pressure as "force per unit area," and then proceed to use force and pressure interchangeably. Problems calling for pressure are proposed and the answers express the force over the whole area, not the force per unit area.

In some texts absolute temperature on the gas thermometer is confused with absolute temperature on the thermodynamic scale. Specific gravity has different meanings in different textbooks. The distinction between difference of potential and electromotive force is not sufficiently clear. Many books use the pound and gram indiscriminately to mean both force and mass. These are both serious mistakes and serious handicaps to the student.

In the whole field of physics there is, perhaps, no place where

the relation between terms used in translation and in rotation is clearer than it is between mass (linear inertia) and moment of inertia (angular inertia). Mass or linear inertia, in translation, is the exact analog of movement of inertia, in rotation. In a book whose title is "Mechanics for Engineers" and whose author is a professor of mechanics in a great engineering college, we find: "The term moment of inertia is somewhat misleading, and the student is apt to try to connect moment of inertia with inertia. The term has no such significance and should be regarded as the name arbitrarily applied to a quantity that engineers frequently use."

In the treatment of dimensional equations, a number of texts on mechanics make the statement that the angle is without dimensions. The equivalent statement may be found in some analytic geometries. The argument is that since *angle* is the ratio of arc to radius, it is length divided by length and therefore it is without dimensions. It should be observed that the arc is always perpendicular to the radius and therefore the dimensions of angle are length in one direction divided by length in a direction at right angles to the first length. This might be written $L_x/L_y$.

If we assume that the angle is without dimensions, it is easy to show that work and torque mean the same thing. Work is force times distance; torque is also force times distance. Hence to one not accustomed to making distinctions, work might appear to mean the same as torque. Work is force times distance where the distance must be measured in the direction in which the force acts. Torque is force times force arm (distance) where the force arm must be measured at right angles to the direction of the force. Hence, if work, $W = FL_x$, then torque, $L = FL_y$.

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## THE PUBLIC HIGH SCHOOL GROWS.

| | 1918 | 1926 |
|---|---|---|
| Number of Schools | 16,300 | 21,700 |
| Number of Teachers | 84,988 | 169,538 |
| Number of Pupils | 1,933,821 | 3,757,466 |
| Cost | $162,875,761 | $697,911.735 |

In this period from 1918 to 1926 the population of the United States increased nearly 14 per cent, the membership in public high schools increased 50 per cent and costs increased 300 per cent. At the present time more than half of our population of ages 15 to 18, inclusive, is actually enrolled in secondary schools.

# SELLING PHYSICS AND CHEMISTRY.

By P. M. Bail,

*Principal University High School, Iowa City, Iowa.*

One of the most frequently asked questions, during the enrollment periods of senior high school pupils, is what is that subject about? What is physics? What does it deal with? What is chemistry? Why should I study it? There are numerous other questions asked. These questions are asked concerning each and every subject offered.

The answer to such questions the pupil has a right to demand. He is enrolling for a period of thirty-six weeks, for five or more hours per week; and if carrying four subjects will spend one-fourth of his school year studying that particular subject. He should know specifically what the subject is about, what benefits he can expect from it, and how it will help him not only so far as immediate value is concerned but also how the deferred values will help him in his vocation or avocation.

Theoretically, our guidance program should take care of this particular item but in the school business, as in any other line of endeavor, the individual teacher must be a salesman for his particular subject or department. The subject must be sold to the pupils and the parents both before enrolling and after enrollment in the subject. One of the best salesmen that a product can have is a satisfied customer. Projects such as this produces satisfied customers who are in turn able and willing to inform other pupils concerning the subject.

The following project was undertaken in order to show how it is possible to sell a subject, not only to the enrolled pupils but also to the whole student body, keeping in mind that the material used must be of value to the pupil not only in the classroom but must unite his outside activities with those of the classroom.

The project was developed gradually, keeping in mind the seven factors of study. First, the recognition of the problem. Each pupil was asked to select for himself some topic relating to chemistry or physics that he was particularly interested in and one that was kept prominently before the public in newspapers and magazines. The pupils discussed their particular topics, and had clearly in mind just what they intended to portray.

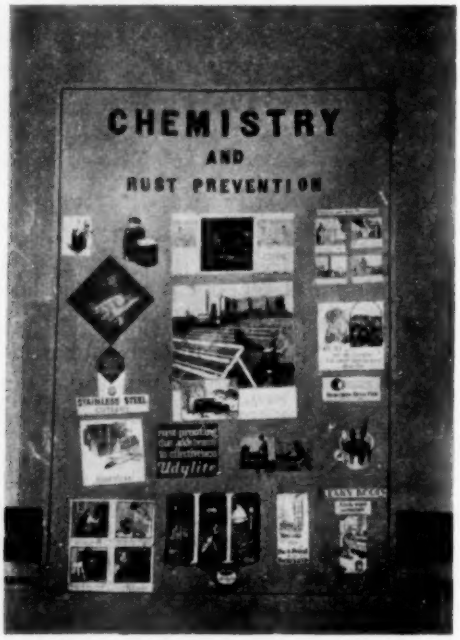
Second, the collection of data. Several weeks were spent in the choosing of topics and the collection of write-ups and advertisements from the periodicals. All varieties of papers, maga-

zines, books and pamphlets were thoroughly searched in order to find just the material to express the idea which the pupil was attempting to put across.

Third, the organization of ideas. The material was organized according to the pupil's idea of how best to show the relation of his topic to the field of chemistry or physics.

Fourth, the scientific doubts or questioning attitude. The material was closely examined and after close questioning certain parts were chosen and other parts rejected.

Fifth, the application of the work. The working out of the result as a real situation, in the try-out of material.




Sixth, the memorizing or clinching of facts. In this stage the activity of making the posters took place. The application of the art courses helped several pupils in arranging their material on the posters, in this case producing a positive transfer from one subject over to another.

These posters were then exhibited to all the pupils enrolled in chemistry, as well as exhibited to the whole student body and the parents who visited the school during the annual school exhibits week.

This project in a small way satisfies one of Van Denburg's

principles of instruction, "each pupil has the unquestionable right and unavoidable obligation to contribute everything within his power toward the education of his classmates." Each pupil actually produced something which provided the other pupils with instructional material.

Concerning the actual working out of the project not much need be said except that pupils spent some two or three weeks thinking about and deciding upon their particular topic, collecting data, organizing the material and actually making the posters. The posters were 18 in. by 36 in. cards purchased for five cents. Other minor costs were for show card ink, brushes and glue. Approximately seventy-five Physics and twenty-five Chemistry posters were made. The accompanying picture gives a good idea of one of the posters.

A project such as this provides purposive thinking for the pupil, and material for the worker that is in itself worthwhile as well as being of real sales value to the physics and chemistry departments in answering the questions concerning the content of physics and chemistry.

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## ANNUAL MEETING OF THE EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The Eastern Association of Physics Teachers 113th meeting will be held at Massachusetts Institute of Technology, Cambridge, Massachusetts, March 8, 1930. This is the Annual meeting.

The program includes annual reports and election of officers.

Address of the Vice President: Demonstration of Apparatus by Representative of the Central Scientific Company.

Address by Dr. A. W. Hurd of Teachers College, Columbia. "Present Inadequacies and Suggested Remedies in the Field of Teaching Physics."

Address by Prof. Norman E. Gilbert, Dartmouth. "The Cyclical Nature of the Universe."

Address by Prof. Arthur C. Hardy, Massachusetts Institute of Technology. "Color, and Demonstration of Colorimeter."

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"Take interest, I implore you, in those sacred dwellings which one designates by the expressive term laboratories. Demand that they be multiplied, that they be adorned: these are the temples of well being and happiness. There it is that humanity grows greater, stronger, better."—*Pasteur.*

## EYE VS. EAR IN BIOLOGY FOR HIGH SCHOOLS.

By L. E. Hildebrand,

*New Trier High School, Kenilworth, Ill.*

It is my intention here to state briefly the reason for the above title of my illustrated talk on Biology.

All my life I have tried to be awake to the results obtained by every form of effort in teaching various subjects, but in Natural Science, especially, it is true that "we do not know till we have seen."

"Seeing is believing" it is said, but what it really means is "knowing." I am prepared to say that, as a rule, only to hear is to preceive a rumor and according to the dictionary a rumor is an "indistinct noise," while according to the same authority "to see" is "to behold." Now this does not mean that everything that the physical eye looks upon is really known and understood, but the difference between merely hearing and also seeing is incalculably great. One illustration will make this clear. A student gives a special report on muskrats, for instance, and the rest of the class show no interest and pay very little attention to him, but the teacher sallies forth to some part of the room and produces a mounted specimen from the shelves and instantly all eyes shine with interest and everybody straightens up in his seat and it is absolutely evident that their minds are in the act of registering impressions and that some of these will be permanent is evidenced by the interest shown. Thus teaching is made easy and a pleasure to the teacher and often a delight instead of a task to the learner.

We have heard much about visual education in recent years but it always seems to leave the impression that such methods are concerned with slides and films. Why not emphasize the use and accumulation of real things of the natural world in comparison to which the pictures on the screen are only shadows? Of course there is always room enough for slides and films of things not attainable, not adapted for the laboratory shelves and walls. What I mean is why not fill our laboratories literally full of materials that will aid in arousing an interest in Natural Science for it must be the chief province of teaching any subject in our curriculum to interest the student; for then the learning process too is almost as good as achieved. What surprises one often in visiting secondary schools, and many colleges as well, is the very small collection of specimens as though the entire

purpose of teaching Natural Science were attained by having only the essential materials to illustrate cardinal principles and nothing for the general interest of all the school and community. It is easily possible to make our Biology Departments centers of community interest by a little effort on our part for soon the students and the entire community will be working with us in acquiring most interesting materials to such an extent that we will not have room to display half the stuff. This happened in our department at New Trier long ago. At present we have over a thousand bird eggs which we cannot display and files of both botanical and zoological and even geological specimens that are hidden from sight either by being piled up in show cases or as in the case of large mounted fish stored in the tower until such a time when the Board of Education shall see fit to build us real up-to-date quarters in which these things can be properly displayed and saved from gradual destruction by dust and vermin.

Just at present we are receiving through the influence of our Principal a small Arctic collection as a present from Captain MacMillan, the Arctic explorer. Just a year ago a patron of the school presented us, in one day, six mounted fish, ranging in size from four to eight feet, caught by himself in the Pacific and Atlantic. Another citizen, a prominent lawyer, who offers annual bird prizes to the school, caught a large seven-foot sail fish off Florida coast and proceeded to have it mounted at the expense of a hundred dollars, and then presented it to us with his best wishes.

Thus at New Trier we have achieved one thing that I have had in mind all these dozen years and that is the Biology Department has, indeed, become a center of scientific instruction to the entire school and community, as well as a place of interest merely to the classes in biology.

We need to do a little more missionary work in this country as a whole before we measure up to European nations in general scientific knowledge and interest because nearly every little village, say nothing of cities, has its museum collection while here we have left it to the big cities and neglected to make our own little communities centers of Interest and Learning.

## A NEW MICROSCOPE.

E. Leitz, Inc., announce the construction of the Leitz wide field binocular microscope with automatic multiple objective nosepiece. The new instrument serves excellently in various fields of scientific endeavor. Its range of usefulness covers biological science, geology, mineralogy, etc. The pronounced stereoscopic effect is a distinct advantage.

## COLLEGE ENTRANCE REQUIREMENTS IN GEOMETRY.

REPORT SUBMITTED BY PROFESSOR DUNHAM JACKSON,
*University of Minnesota, Minneapolis, Minn.*

A proposal has been made to the College Entrance Examination Board that it should modify its requirements so as to bring about the more extensive introduction of courses including an appreciable amount of solid geometry in the first year of geometry, in place of a part of the plane geometry ordinarily taught. In response to a request from the Board, a committee has been appointed by the Mathematical Association of America and the National Council of Teachers of Mathematics to discuss the feasibility of the proposal. The membership of the committee is as follows: Miss Gertrude E. Allen, University High School, Oakland, Cal.; C. M. Austin, High School, Oak Park, Ill.; Ralph Beatley, Graduate School of Education, Harvard University, Cambridge, Mass.; Walter F. Downey, English High School, Boston, Mass.; Mrs. Elizabeth L. Hall, East High School, Rochester, N. Y.; J. O. Hassler, University of Oklahoma, Norman, Okla.; Dunham Jackson (Chairman), University of Minnesota, Minneapolis, Minn.; C. N. Moore, University of Cincinnati, Cincinnati, Ohio; W. D. Reeve, Teachers College, Columbia University, New York, N. Y.; Edwin W. Schreiber, State Teachers College, Macomb, Ill.

The primary function of this committee is not to draw up detailed recommendations for the proposed new requirement, but to discover if there is sufficient interest in the project on the part of colleges and schools to justify the Board in proceeding with a careful study of it.

The inclusion of any significant amount of new material in the first-year course clearly implies the elimination of much that has been regarded as of genuine importance. The question is not whether the existing course can absorb the additional material, but whether it can clear a place for it without sacrificing its own essential character.

Those who believe in the existing courses in geometry at all will agree that the pupil ought to carry away with him:

An adequately comprehensive knowledge of geometric ideas, facts, and processes;

An intimate acquaintance with the nature of deductive reasoning, as applied not only to detached items of argument, but also to the sustained building up of an extensive and coherent logical structure;

Familiarity with the independent use of deductive reasoning through the study of substantial "originals";

Some facility in the application of geometrical knowledge in the world of experience.

It is suggested that it may be found possible to preserve these essentials, with considerably more liberal recognition than has been customary hitherto of the principle that an elementary course need not aim at the final articulation of *all* the facts that it embraces into a single logical framework. It may be possible to arrive at a readjustment of emphasis which will admit some of the important ideas of three-dimensional geometry in the first year, and at the same time bring geometry closer to the rest of mathematics and to the other sciences.

While the present committee does not aim at a detailed working out of the project, it invites discussion by individuals and groups of teachers who may be interested. It especially desires opinions from teachers who have experimented with a one-year combined course in plane and solid geometry. Communications may be addressed to the chairman or to any member of the committee.

## SPECIAL APPARATUS FOR GENERAL SCIENCE.

For many years teachers of General Science have felt the need of special apparatus and equipment for presenting General Science demonstrations. Joseph R. Lunt and Dennis C. Haley of The Teachers' College, Boston, have recently developed a series of thirty-one self-contained units or outfits, designed to cover the experimental work in any modern General Science text or course of study. Four typical units cover Air and Oxygen, Fuel and Fire Kindling, Constellation and Star Study, Magnets and Magnetism. Each field is carefully developed by pertinent, practical experiments. A teachers' manual for each unit gives full instructions, information, and suggestions as to methods of procedure.

Each outfit includes a portable steel cabinet, neat and attractive in appearance, containing pamphlets, instruction sheets, and charts, as well as all apparatus and supplies.

The Unit Plan has many unusual advantages. It provides vital, practical demonstrations every day without delays and postponements. It practically eliminates preparation time because all materials and apparatus are ready for immediate use. Definite instructions are given for each experiment. The teacher simply takes from the cabinet the material needed for the day's experiments and when the period is over repacks the articles in the same cabinet. The loss and misplacement of articles in drawers and closets is eliminated. When the teacher is ready to repeat the experiment in another class he feels sure that everything is ready for immediate use. The Lunt & Haley Cabinets solve the storage problem in a most effective way. No special cabinets or storerooms are needed. The apparatus is packed in a small space, protected from dust and corrosive fumes.

Extravagance and waste in ordering supplies is avoided. It has been common practice to order General Science Apparatus from Physics, Chemistry, and Biology Catalogues while a considerable part of this apparatus is not well suited to the teaching of General Science. In this way alone thousands of dollars are spent each year for pieces of equipment of little use in this specialized field.

Another serious waste often occurs when there is a change of science teachers. One teacher may buy costly equipment which his successor finds entirely unsuited to his needs. The demonstration apparatus units designed by Lunt & Haley offer a splendid solution to this problem so often arising when there is a change of science teachers. There is another important feature of the Lunt & Haley Units which should appeal to every superintendent and principal. Using the cabinets makes it possible to utilize the same equipment in all General Science sections. This eliminates costly duplication. Moreover the same equipment may be used over and over again year after year. This makes for economy, because it eliminates the need for buying extra material and duplicating equipment in two or more separate science rooms. The authors or manufacturers will gladly send full details to any science teachers or school officials.

## CITRUS BY-PRODUCTS.

In a recent year one of the citrus by-products plants of California utilized more than 40,000 tons of cull lemons, and produced 2,000,000 pounds of citric acid, 65,000 pounds of lemon oil, and 30,000 pounds of pectin. The value of these products exceeded $750,000. Another company used 10,000 tons of surplus oranges in one year and produced 50,000 pounds of orange oil valued at more than $100,000. This was done from materials which, prior to research by the Department of Agriculture were waste products.

## PROBLEM DEPARTMENT.

Conducted by C. N. Mills,

*Illinois State Normal University.*

*This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.*

*All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor* should have the author's name introducing the problem or solution *as on the following pages.*

*The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.*

## CORRECTION.

In the November issue, 1929, page 867, the sixteenth line from the top should read: "QR is equal to the perimeter of the triangle PST."

## LATE SOLUTIONS.

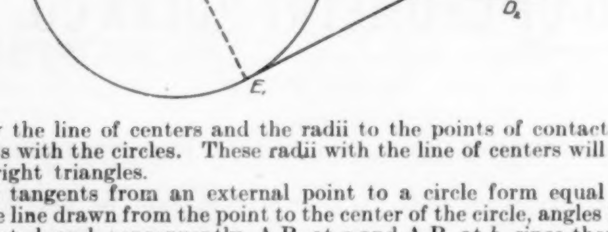
**1078.** *I. Wallach, Brooklyn, N. Y.* This solution will be printed later.
**1088.** *L. Wayne Johnson, Norman, Okla.*
**1086, 1088.** *E. de la Garza, Brownsville, Texas.*
**1090.** *Glenn F. Hewitt, Chicago, Ill.*
*Louis R. Chase, Newport, R. I.*

**1091.** *Proposed by the Editor.*

*Note.* Professor Aubrey Kempner's Problem as suggested in the Mathematics Teacher for March, 1929.

Given two non-intersecting circles, $C_1$ and $C_2$, having centers at $O_1$ and $O_2$, the center of each of which does not lie in the other circle. From the center of each circle draw tangents to the other circle. Tangents from $O_1$ to circle $C_2$ determine on $C_1$ the chord $A_1B_1$. Tangents from $O_2$ to $C_1$ determine on $C_2$ the chord $A_2B_2$. Prove that $A_1B_1 = A_2B_2$.

*I. Solved by Clyde Bridger, Walla Walla, Washington.*




Draw the line of centers and the radii to the points of contact of the tangents with the circles. These radii with the line of centers will form a set of right triangles.

Since tangents from an external point to a circle form equal angles with the line drawn from the point to the center of the circle, angles 1 and 2 are bisected, and, consequently, $A_1B_1$ at $a$ and $A_2B_2$ at $b$, since these lines form the bases of the isosceles triangles $O_1A_1B_1$ and $O_2A_2B_2$, respectively. Further, $A_1B_1$ and $A_2B_2$ are perpendicular to $O_1O_2$.

Right triangles $O_1E_2O_2$ and $O_2A_2b$ are similar since they are a common angle, also $O_1D_1O_2$ and $O_1A_1a$ for the same reason.

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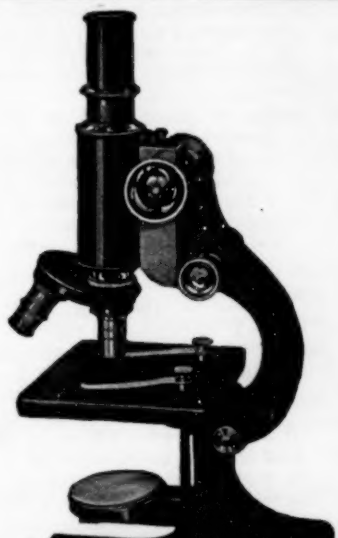

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From these triangles are obtained the relations:
(1) $A_2b : O_1E_2 :: O_2A_2 : O_1O_2$
(2) $A_1a : D_1O_2 :: O_1A_1 : O_1O_2$
Since $O_1E_2 = O_1A_1$ and $D_1O_2 = A_2O_2$, radii of circles $C_1$ and $C_2$, respectively, there results upon simplification: $A_2b = A_1a$; or $A_1B_1 = A_2B_2$.
*Solution II. H. A. Poppen, Woodston, Kansas.*
*Editor:* Notation for figure in solution I.
$K_1$ middle of $A_1B_1$; $K_2$ middle of $A_2B_2$; $d = O_1O_2$; $r_1 = O_1E_1$; $r_2 = O_2D_2$. Denote one half of $\angle A_1O_1B_1$ as $Z_1$.
In the right triangle $A_1K_1O_1$, we have $A_1K_1 = r_1 \sin Z_1$.
Also, $\sin Z_1 = r_2/d$, and $A_1K_1 = (r_1r_2)/d$.
In the right triangle $O_2K_2A_2$, we have $A_2K_2 = r_2 \sin Z_2$.
Also, $\sin Z_2 = r_1/d$, and $A_2K_2 = (r_2r_1)/d$.
Hence, $A_1K_1 = A_2K_2$, from which we know that $A_1B_1 = A_2B_2$.
Also solved by *E. Justin Hills, Compton, Calif.; Louis R. Chase, Newport, R. I.; A. MacNeish, Chicago, Ill.; Honor Mathematics Society, Jennie Kennedy, Sec'y., Redwood City, Calif.; R. T. McGregor, Elk Grove, Calif.; A. J. Patterson, Wheeling, W. Va.; W. E. Buker, Lettsdale, Pa.; M. G. Shucker, Pittsburgh, Pa.;* and *George Sergent, Tampico, Mexico.*

**1092.** *Proposed by Norman Anning, University of Michigan.*
Find the exact value of the following expression for $t^3 = 2$:
$$\frac{(4t-5)^3}{(1-t)^3}.$$
*Solved by Honor Mathematics Society, Jennie Kennedy, Sec'y., Redwood City, Calif.*
Expanding the numerator and the denominator, and substituting for every $t^3$ the value 2, we get
$$\frac{240t^2-300t-3}{80t^2-100t-1} = 3.$$
Also solved by *George T. Johnson, Brainerd, Minn.; M. G. Shucker, Pittsburgh, Pa.; E. A. Hollister, Pontiac, Mich.; Louis R. Chase, Newport, R. I.; John Carson, Spokane, Wash.; Raymond, Huck, Johnston City, Ill.; Floyd H. Sheel, Assaria, Kansas; Floy Hanson, Wilmore, Kansas;* and the *Proposer.*

**1093.** *Proposed by G. W. Wishard, Norwood, Ohio.*
$7^4+7^3+7^2+7 = 2800.$
Find other numbers which have the same property.
*Solved by W. E. Buker, Lettsdale, Pa.*
I assume the proposer to mean that we must find values of $r$ and $n$ satisfying the equation
$r+r^2+r^3+ \ldots\ldots +r^n = 100\,r\,n$. Division by $r$ gives us $1+r+r^2+ \ldots +r^{n-1} = 100n$, or
$$\frac{r^n-1}{r-1} = 100n, \text{ or}$$
$r^{n-1}+r^{n-2}+ \ldots +r-(100n-1) = 0$ where $n$ and $r$ are integers. Setting $n = 2$, $r-199 = 0$; $r = 199$.
Hence, $199^2+199 = 100 \text{x} 199 \text{x} 2$, or
$199^2+199 = 39800$ and satisfies the conditions of the problem.
If $n = 3$, $r^2+r-299 = 0$. $299 = 13 \text{x} 23$. Neither satisfies the equation, and there is no solution for $n = 3$.
$n = 4$, $r^3+r^2+r-399 = 0$. $r = 7$, and we have the given property.
$n = 5$, $r^4+ \ldots -499 = 0$. 499 prime, no solution.
$n = 6$, $r^5+ \ldots -599 = 0$. 599 prime, no solution.
Continuing, it is apparent that there are no more solutions, for as $n$ increases $r$ must decrease. It is interesting to note that $100n-1 = 0$ (mod $r$); and $r$ is never even.
The only solution in integers of $r+r^2+r^3+ \ldots +r^n = 100rn$. are $n = 2$ $r = 199$.
$n = 4$, $r = 7$.
Also solved by *Norman Anning, University of Michigan.*

**1094.** *Proposed by P. H. Nygaard, Spokane, Wash.*

In a certain state A and B are candidates for the same office. It is expected that 450,000 votes will be cast for this office. The pre-election odds are even on the chances of A and B to win. The odds are also even that neither candidate will receive over 20,000 majority. (1). What is the probably of a tie vote? (2). What is the probability that the returns will be such that a switch of 1,000 votes from A to B would be enough to change the result from defeat to victory for B? (3). What should be the odds on A to win by at least 50,000 majority?

*Solved by the Proposer.*

(1). The 450,000 has nothing to do with the problem. The probable error of the distribution is 10,000. Assuming a normal distribution, the standard deviation would be 14,825. From the equation of the normal distribution curve we find that the probability of a tie, that is A getting exactly 225,000 votes, is $\dfrac{1}{14{,}825\sqrt{2\ \mathrm{pi}}}$, or .000027. This is about 1 chance in 40,000.

(2). Since 1000 is .1 of the probable error, we find the area under the probability curve from $x = -.1$ of the probable error to $x = 0$. A table of values of the probability integral shows this to be .027 of the total area, or about 1 chance in 40.

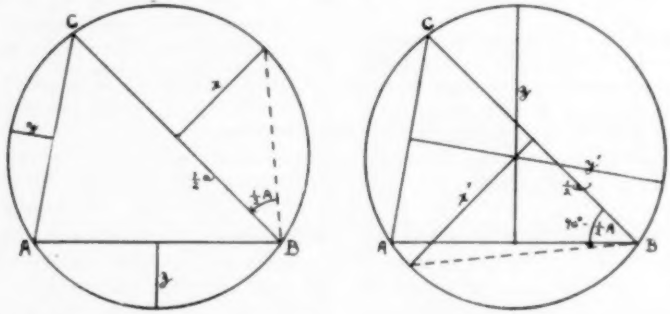
(3). To find the probability of A getting at least 250,000 votes, we find the area under the probability curve from $x = +2.5$ of the probable error to $x =$ infinity. This is .04 of the total area, or odds of 1 to 25.

**1095.** *Miscellaneous.*

The product of the distances of the midpoints of the minor arcs subtended by the sides of an inscribed triangle from those sides, is equal to one-half the product of the radius of the circumcircle and the square of the radius of the incircle. Prove.

Obtain the relationship corresponding to taking the midpoints of the major arcs.

*Solved by Louis R. Chase, New Port R. I.*




From the diagram it is plain that

$x = \frac{1}{2}a \tan \frac{1}{2}A$, $y = \frac{1}{2}b \tan \frac{1}{2}B$, $z = \frac{1}{2}c \tan \frac{1}{2}C$.

Multiplying,

$xyz = 1/8\, abc \tan \frac{1}{2}A \tan \frac{1}{2}B \tan \frac{1}{2}C$.

Putting $r/(s-a)$, $r/(s-b)$ and $r/(s-c)$ for the tangents respectively,

$$xyz = \frac{abc\, r^3}{8(s-a)(s-b)(s-c)}$$

$$= \left(\frac{abc\, r}{4\ (s-a)\ (s-b)\ (s-c)}\right)\frac{r^2}{2}$$

Now putting $1/s[s\ (s-a)\ (s-b)\ (s-c)]^{1/2}$ for the first $r$, and then putting

R for $\dfrac{abc}{4[s\ (s-a)\ (s-b)\ (s-c)]^{1/2}}$, we have $xyz = Rr^2/2$.

$x' = \frac{1}{2}a \tan(90° - \frac{1}{2}A) = \frac{1}{2}a \cot \frac{1}{2}A$
$y' = \frac{1}{2}b \tan(90° - \frac{1}{2}B) = \frac{1}{2}b \cot \frac{1}{2}B$
$z' = \frac{1}{2}c \tan(90° - \frac{1}{2}C) = \frac{1}{2}c \cot \frac{1}{2}C$

Multiplying,

$x'y'z' = 1/8\ abc \cot \frac{1}{2}A \cot \frac{1}{2}B \cot \frac{1}{2}C.$

Now substituting $(s-a)/r$, $(s-b)/r$ and $(s-c)/r$ for the cotangents, then substituting for every $r$ and substituting R as above, we have $x'y'z' = Rs^2/2$.

Also solved by *Norman Anning, University of Michigan*, and by *George Sergent, Tampico, Mexico.*

**1096.** *Proposed by A. J. Spracklin, Sidney, Nova Scotia.*

If a person were to borrow $1,500 and pay $20 per month for 49 months, and then pay $15 per month for 62 months, how much does he still owe (interest 7 per cent annually)?

*Solved by Glenn F. Hewitt, Chicago, Ill.*

Following the method of E. A. Row, on page 952 of the December, 1925, issue (which method is but an application of the laws of geometric progressions), and using the notation given there, we let P = $1500, the original debt; M = $20, the size of each of the first 49 equal payments; $r = .07$, the rate of interest; $t = 1/12$, the time *in years* between payments; $n = 49$, the number of payments; $P_1$ = the amount of the first payment which is made on the principal; $P_{49}$ = the 49th payment; $S_{49} = P_1+P_2+ \ldots . + P_{49}$. Then $P_1 = M - Prt = \$11.25$. Then $P_{49} = P_1(1+rt)^{48} = \$14.88$.

$$S_{49} = \frac{P_1 - (1+rt)P_{49}}{1-(1+rt)} = \$637.17.$$

Hence, $1500 − $637.17 = $862.83, balance after 49 payments.

Let P = $862.83, the new balance; M = $15, new payment; $r = .07$; $t = 1/12$; $n = 62$; $P_n$, amount paid to principal out of $n$th payment; $S_{62} = P_1+P_2+ \ldots \ldots . P_{62}$. Then $P_1 = M - Prt = \$9.97$.

$$P_{62} = \$9.97\left(\frac{1207}{1200}\right)^{61} = \$14.22 \quad S_{62} = \frac{P_1-(1+rt)P_{62}}{1-(1+rt)} = \$742.79.$$

Hence, $P - S_{62} = \$120.04$, balance due.

The result would be the same by the United States rule for partial payments in Arithmetic, which, if not used in Nova Scotia, may cause Mr. Spracklin to consider a different answer correct. These computations have been made using a 5-place logarithm table.

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## PROBLEMS FOR SOLUTIONS.

**1109.** *Proposer unknown.*

Are there any flaws in this proof: (See proof on p. 212)

**1110.** *Proposed by H. D. Grossman, Brooklyn, N. Y.*

What proportion of all rational fractions are in their lowest terms?

**1111.** *Proposed by L. M. Hollingsworth, San Diego, Calif.*

Nine marbles one inch in diameter are placed in a layer at the bottom of a box 3 in. square. Four more marbles are placed above these, and a fourth marble at the top, all of same diameter, and placed to form a pyramid of least height. How many points of contact among the marbles? What is the height of the pyramid?

**1112.** *Proposed by Norman Anning, University of Michigan.*

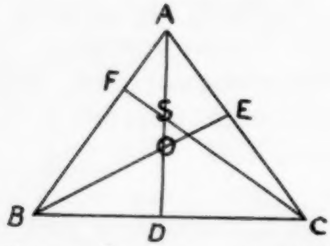
In a design of a double turnout from a straight track the engineer comes upon the following formula (See Webb, Railroad Construction, page 306): 2 vers$A$ = vers 2$B$. Prove $\cot^2 A(1+2\cot^2 B) = \cot^4 B$.

**1113.** *Proposed by I. N. Warner, Plateville, Wis.*

Disprove the old theorem found in earlier geometries.

The number of edges of any convex polyhedron is 2 fewer than the sum of the numbers of its faces plus the number of its vertices, or $E+2 = F+V$.

The Altitudes of a Triangle are Concurrent.




Given triangle ABC with altitudes AD and BE intersecting at O, and altitudes CF and AD intersecting at S.

Right triangle SDC is similar to triangle BFC, which is similar to triangle ABD; therefore

$$\frac{SD}{BD}=\frac{CD}{AD}$$

Right triangle BOD is similar to triangle BEC, which is similar to triangle ADC; therefore

$$\frac{OD}{BD}=\frac{CD}{AD}$$

It is evident that $\frac{SD}{BD}=\frac{OD}{BD}$, and $SD=OD$; so the point S must fall at O.

**1114.** *Proposed by Clyde Bridger, Walla Walla, Wash.*

A ladder of length L stands upright beside a wall of a building. The wall of the building and the surrounding ground are considered as being at right angles to each other. (a) To what curve is the ladder tangent as it slides down the wall and along the ground (in a plane $\perp$ to line of intersection.

(b) What is the locus generated by any point (except the two end points on the ladder if it falls as in (a). Give its equation.

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A frog has teeth in the upper jaw while toads have not.

One star fish lays two hundred million eggs a year.

When an enemy is near a walking-stick it goes into a death feint and will not move even though its body should be cut in two.

## BOOKS RECEIVED.

High School Geography by R. H. Whitbeck, Professor of Geography in the University of Wisconsin. Cloth. Pages x+574. 13x19.5 cm. 1929. The Macmillan Company, 60 Fifth Avenue, New York. Price $2.00.

Introduction to the Theory of Numbers by Leonard Eugene Dickson, Professor of Mathematics, University of Chicago. Cloth. Pages viii+183. 13x19.5 cm. 1929. The University of Chicago Press, Chicago Illinois. Price $3.00.

High School Science Terminology, Chemistry and Physics, Part I by J. O. Frank, Professor of Science Education and Head of the Department of Chemistry, Wisconsin State Teachers College at Oshkosh, assisted by H. K. White for several years teacher of Science in the Missoula County High School, Missoula, Montana. Cloth. 208 pages. 15x23 cm. 1930. J. O. Frank, Oshkosh, Wisconsin. Price $2.50.

Beginning Chemistry by Gustav L. Fletcher, Chairman, Department of Physical Science, James Monroe High School, New York, Herbert O. Smith, Chairman, Department of Physical Science, Newtown High School, New York and Benjamin Harrow, Assistant Professor of Chemistry, College of the City of New York. Cloth. Pages viii+476. 13x20 cm. 1929. American Book Company, 330 East 22nd Street, Chicago, Illinois. Price $1.60.

Plane Geometry by Charles Solomon, Chairman of the Department of Mathematics, Boys High School, Brooklyn, New York and Herman H. Wright, District Superintendent Assigned to High Schools, New York City. Cloth. Pages viii+340. 12x18.5 cm. 1929. Charles Scribner's Sons, 597 Fifth Avenue, New York. Price $1.40.

Directed Study Guides for Pitkin and Hughes' Seeing America Farm and Field by Alma Leonhardy, Grace W. Hogoboom and Elizabeth Van Patten. Paper. 64 pages. 21.5x28 cm. 1929. The Macmillan Company, 60 Fifth Avenue, New York. Price 48 cents.

The Mathematics of Investment by William L. Hart, Professor of Mathematics in the University of Minnesota. Revised. Cloth. Page xii+253+88. 13.5x20.5 cm. 1929. D. C. Heath and Company, 285 Columbus Avenue, Boston, Massachusetts. Price with tables $3.52; without tables $2.60; tables bound separately $1.48.

Elementary Laboratory Aerodynamics by Arthur L. Jordan, Science Department, Polytechnic High School, San Francisco. Paper. 67 pages. 14.5x21.5 cm. 1929. The Ronald Press Company, 15 East 26th Street, New York. Price 80 cents.

Extension Methods and their Relative Effectiveness by M. C. Wilson in Charge Extension Studies. Technical Bulletin No. 106. September, 1929. Paper. 48 pages. 15x23 cm. United States Department of Agriculture, Washington, D. C. Price 15 cents.

Lane-Greene Unit—Achievement Tests in Plane Geometry by Ruth O. Lane, and H. A. Greene. Unit Sample Set. 6 Tests, Forms A and B. Paper. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price 44 cents.

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## BOOK REVIEWS.

*"A Chemical Dictionary" containing the words generally used in chemistry, and many of the terms used in the related sciences of physics, astrophysics, mineralogy, pharmacy, and biology, with their pronunciations based on recent chemical literature by Ingo W. D. Hackh, Professor of Chemistry, College of Physicians and Surgeons, A School of Dentistry, of San Francisco, California. Author of "Chemical Reactions and their Equations." With elaborate tables, diagrams, portraits, and many other illustrations.* 1st Edition. Pp. viii + 790. 19x25.5x4.2 cm. Cloth. 1929. $10.00. P. Blakiston's Son & Co., Inc., Philadelphia.

This new chemical dictionary is also so much a dictionary of chemistry that it will be an indispensable addition to every chemistry department library of any standing. Professors of Chemistry will want it for their

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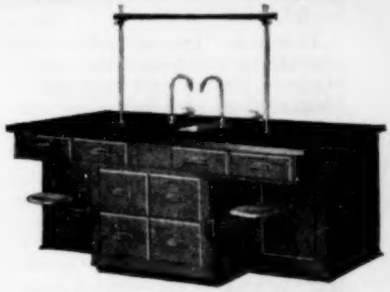

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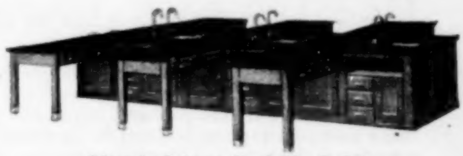

**Lincoln Science Desk No. D-540**

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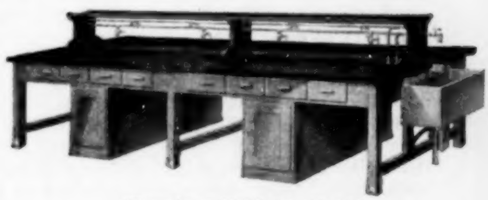
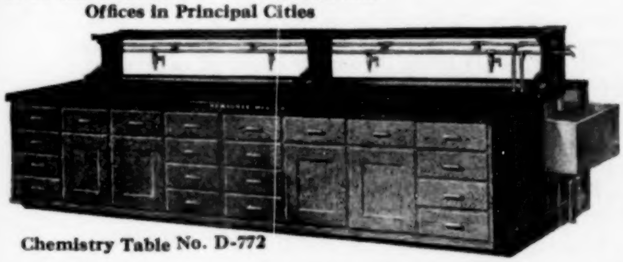
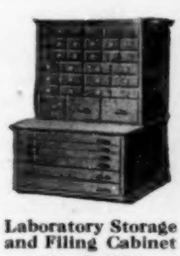


**Chemistry Table No. D-677**



**Chemistry Table No. D-772**



**Laboratory Storage and Filing Cabinet No. G-1323**

private libraries and industrial research libraries will also find it very useful.

It is more than an ordinary dictionary for it has many long paragraphs containing condensed accounts of fundamentals of chemical principles, theories, history and biography. Many excellent portraits accompany the biographical sketches.

There are many diagrams and pictures of apparatus, tables, structural formulas, etc.

The content is right up to date, surprisingly so for such a monumental work. The latest physical chemistry is represented—the Schrodinger atom for example, with a good condensed account of the subject. Sampling here and there we found a good Laue diagram with accompanying diagramatic sketch of the apparatus by which it is made, a Debye crystallogram and an excellent discussion and correlation of the different methods of obtaining crystallograms. Throughout, the book is excellently cross referenced.

Medical college libraries will find the dictionary especially strong on the side of medical chemistry and pharmacy.

Law offices which specialize in medico-chemical cases will find the book almost indispensable.

The author, in his preface, says, "—my aim has been not to make a mere compilation or collection of facts, but to restate and redefine in simple modern terms the phenomena of science, and to connect these phenomena with each other. My hope is that it will find favor and prove to be the practical and reliable aid for the scientist and student which it was meant to be."

The reviewer's prediction is that the author's hope will be fulfilled and that this book is to become a classic. F. B. W.

*Statistics for Beginners in Education, by Dr. Frederick Lamson Whitney, Colorado State Teachers College, Greeley, Colorado.* Cloth, Pages xvi + 123. 12.5x18.5 cm. 1929. D. Appleton and Company.

This book satisfies a real need. Its purpose is to give a reading knowledge or word conception of the most frequently used statistical terms found in the commonly read journals and books on education. In brief, the purpose is to develop a statistical vocabulary. Despite a claim of the author, "that the aim is not to develop skill in the use of the statistical method in education," the book may be used to serve this purpose for the beginner in education.

The sixty-two terms included in the book were determined by an analysis of the terminology used in a representative sampling of the current educational journals read by high-school and elementary-school teachers.

The first part of the book introduces the sixty-two terms through a survey of pupil-differences. This part serves the purpose of a diagnostic difficulty analysis, since it will reveal the terms which are unknown and unfamiliar. The reader is also asked to make a list of the terms he does not know.

The second part of the book is devoted to developing the meanings of the terms relating to collecting, organizing, classifying data, graphic presentation of data, averages, variation from the average, relationships. Tables, graphs, and illustrative material will be found and there is a glossary of the terms appended. Furthermore, a test of the understanding of the terms used in each chapter is made through a check of each word, whose meaning is clear, in the vocabulary list provided for each chapter and all words understood are also checked on the previous vocabulary list to which reference has already been made. A sample of the direction is "check each term off the list that has been added to your vocabulary in educational statistics and check them off the list on page 38, if your conscience permits." Readers may question the validity of such formal tests of word conception made under "what to do."

William E. Smythe.

*Practical Chemistry, by Lyman C. Newell, Ph. D. (Johns Hopkins) Professor of Chemistry Boston University, Boston, Mass. Author of "Experimental Chemistry," "Descriptive Chemistry," "General Chemistry," "Inorganic Chemistry for Colleges," "Laboratory Manual of Inorganic Chemistry," "College Chemistry," "Experiments in College Chemistry," "Practical Chemistry," "Brief Course in Chemistry," "Laboratory Exercises for Brief Course in Chemistry."* Revised Edition. Pp. viii + 543. Together with "Experiments in Practical Chemistry." Pp. viii + 168. 15.5x19x3.3 cm. Illustrated. Cloth. Revised 1929. D. C. Heath & Co.

This revised edition of a well known text brings it up to date—much new material has been added and much of the old revised. Among the new material may be mentioned a new and up-to-date discussion of atomic numbers, of helium, neon, atomic hydrogen, vitamins, chromium plating, cellulose, X-Ray spectra, and quartz. The chapters on chlorine, nitric acid, valence, ions, and the classification of the elements have all been revised. New material on electrons has been introduced in the proper places and the chapter on radium has been rewritten. A new chapter on the constitution of matter has been added. F. B. W.

*Corrective Arithmetic, Vol. III, for Supervisors, Teachers, and Teacher Training Classes, by Worth J. Osburn, Professor of School Administration, Ohio State University, and Director of Research, State Department of Education, Columbus, Ohio.* Pp. vi+274. 15.5x19.5 cm. 1929. $1.80. Houghton Mifflin Company, Boston.

"This volume, like the first one, rests upon an extensive research program. Careful error studies are back of the chapters on 'Problem Solving,' 'Common Fractions,' 'Decimal Fractions,' 'Arithmetic as a Preparation for Higher Mathematics' and 'What to Teach in the Grades.' All of the Chapters are built upon a prolonged study of the differences in the learning power of bright and dull pupils."

The first chapter is a vigorous and interesting statement of the need of a corrective procedure. Chapter II, on Problem Solving, makes the point that transfer is essential in all types of thinking. Slow pupils are, in general, those who do not see the identity of elements and procedures in two or more situations. In the chapter on Decimal Fractions the author asserts that decimal fractions should be taught before common fractions. In the following chapters we find many other interesting statements. Thus, Proportion has a good right to be considered as one of the fundamentals of arithmetic. Arithmetic is not a tool subject in the sense that handwriting is. It should be a vital part of the pupil's education. Reading and construction of graphs, meaning of variables, concept of unity, equations and formulas, development of the meaning of literal terms, teaching of rules and generalizations, estimating answers, problems without numbers, and negative numbers, are types of subject matter that should be introduced in arithmetic.

This book is thought provoking. Every teacher of mathematics should read it. J. M. Kinney.

*Modern Mathematics, by Raleigh Schorling, Head of Department of Mathematics, The University High School, and Professor of Education, University of Michigan, and John R. Clark, The Lincoln School, Teachers College, Columbia University.* Seventh School Year, New Edition. Pp. xiv+274. 88 cents. Eighth School Year, New Edition. Pp. xiv+306. 92 cents. World Book Company, Yonkers-on-Hudson, New York.

These texts are revisions of Modern Mathematics by the same authors. Much of the material of the first commercial edition has been retained. However, there are some important changes which are to be noted.

During the past decade a great improvement has been made in the field of Junior High School Mathematics in the selection of material through which the pupil may be trained in quantitative thinking. These authors have been very active in bringing about this improvement. The results of their activities are made evident in these texts.

The following recital of the features of this two year course sets forth the character of this material.

The first chapter of the first book is concerned with the making of careful measurements. The importance of measurement is stressed. Squared paper is introduced and the advantages of the metric system are related. The measurement of angles is treated in Chapter III, the measurement of areas of simple figures in Chapter XV, and the measurement of volumes in Chapter VI. In the second book Chapter III and Chapter IV treat indirect measurement through the use of similar triangles and the trigonometric ratios.

During the past twenty-five years much has been written concerning the desirability of stressing the function concept in secondary mathematics. The National Committee in its report emphasized the importance of this fundamental principle to the extent of devoting one whole chapter to it. In Europe the notion of functionality has been given much attention from the sixth or seventh grade up. In these texts we find this notion has been cultivated from the beginning by means of tables, graphs, and formulas which have been applied to a variety of situations of interest to young people.

Much material based upon the social experiences of young people is used as a basis for projects. Illustrations are to be found in Boy Scout meetings, school gardens, operating cars, school budgets, and the like. Thus the course is made practical.

Much could be said concerning the application of psychological principles to the arrangement and presentation of material. We state the matter briefly by quoting some of the features noted by the authors in the preface.

1. The course challenges the pupil. Personal, thought-provoking, problem-solving appeal is made to the pupil.

2. The texts are written with a vocabulary which children can understand.

3. The texts are organized in harmony with the way in which children naturally learn.

4. The books make unusual provision for individualized instruction. There are lists of verbal problems accompanying each topic: "Easy Exercises," "Harder Exercises," and "Exercises for Superior Pupils." This is one of the new features of the revision.

5. The texts include a very effective program for fixing the fundamentals. This is also a new feature of the revision.

The reviewer feels that here are two texts that are unsurpassed in the field of Junior High School Mathematics. J. M. Kinney.

*Automorphic Functions. By Lester R. Ford, Assistant Professor of Mathematics, Rice Institute.* Pp. xii+333. 16x23.5 cm. 1929. $4.50. McGraw-Hill, New York.

This is the only book in English on the theory of Automorphic Functions. It is of special interest to those who are working in the field of a complex variable. J. M. Kinney.

## NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.

The New York State Science Teachers' Association held its annual meeting at Syracuse December 26th and 27th. President Harlan P. Freeman of Niagara Falls High School presided.

Several resolutions of importance were passed, among which were the following:

RESOLVED:

1. That the New York State Science Teachers' Association continue the work of the Teacher Placement Committee.

2. That the New York State Science Teachers' Association approve of the action taken by the State Examinations Board with reference to a sequence in Science, involving specifically,

    1. The establishing of a tenth year course in General Biology to follow General Science in the ninth year.
    2. The granting of two units in Science upon the completion of an advanced Science such as General Biology, Physics, Chemistry, Physical Geography or Advanced Biology, providing these courses have been preceded by General Science in the ninth year.

3. That the New York State Science Teachers' Association recommend the changing of the requirement for the College Entrance Diploma so as to read "Latin or Greek or French or Spanish or German or Italian Three Years or Three Years of Science."

The Association expressed by resolutions its appreciation to the Associated Academic Principals, to Supt. Alverson of Syracuse and to others for assistance rendered and also to all who contributed to the program

The program consisted of addresses as follows:

Mr. Warren W. Knox, State Supervisor of Science, spoke on "Problems of Science Sequence."

Prof. A. J. King of Syracuse University gave an address on "The Use of X-Rays in Chemistry."

Mr. A. K. Getman of the State Department of Education talked on the subject of "Elementary School Science."

A symposium was led by Mr. K. M. Humphrey and by Miss Hewitt, both of Vocational High School, Syracuse, on the topic, "Supplementary Reading in Science." Mr. John A. Baird, East High School, Rochester, discussed the subject "Failures in our Sciences."

Mr. Ellis L. Manning of the General Electric Research Laboratory, Schenectady, closed the program with an address on "Vacuum Tubes."

The keynote of the meeting was the desire to have the sequence of Science subjects and the College Entrance Diploma so arranged that the Science-minded pupil may have equal opportunity with the Language-minded pupil; i. e., that he may present three years of Science instead of three years of Language for his diploma. For the coming year the Association will work for the adoption of such a plan and for the advancement of the Science teachers who become members.

The following officers were elected for the coming year: President, K. M. Humphrey, Vocational High School, Syracuse; Vice-President, A. J. Burdick, Utica Free Academy; Secretary-Treasurer, Miss Lucy E. Latham, Sherrill High School; Members of the Council for 1930-1932, Harlan P. Freeman, Niagara Falls High School; George W. Fowler, Central High School, Syracuse, and W. Earle Sutherland, Albany High School.